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(54) **HIGH-CAPACITY OPTICAL READ/WRITE PICK-UP MECHANISM AND ASSOCIATED METHODS**

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(22) Filed: **Feb. 18, 2003**

(65) **Prior Publication Data**

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(51) **Int. Cl.**[7] **G11B 7/00**

(52) **U.S. Cl.** **369/44.19**; 369/44.14; 369/44.17

(58) **Field of Search** 369/44.11, 44.14, 369/44.17, 44.19, 44.27, 47.1, 53.1

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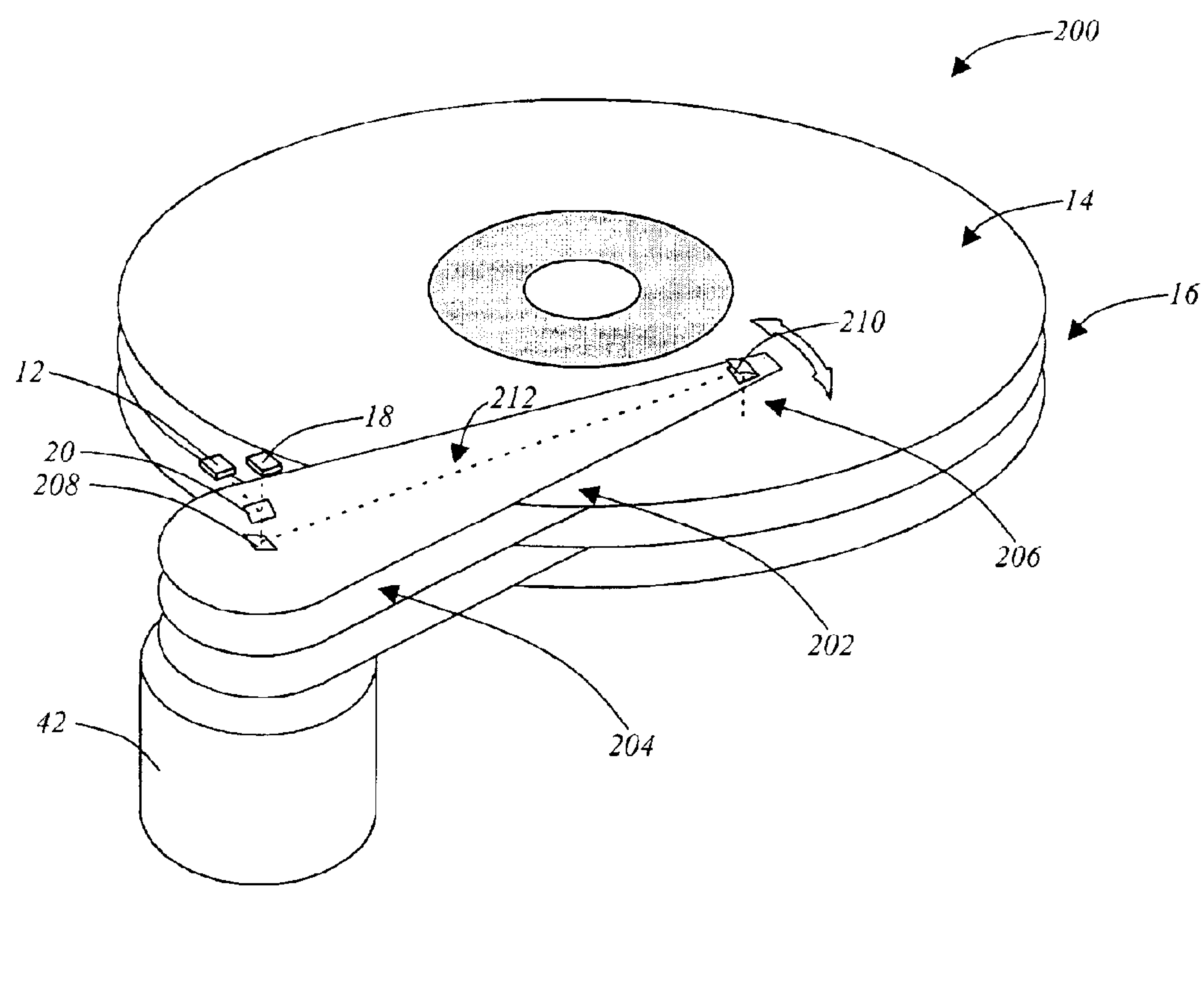
(74) *Attorney, Agent, or Firm*—Fletcher Yoder

(57) **ABSTRACT**

High-capacity pick-up mechanisms operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media are disclosed. These mechanisms comprise a first pivotable structure, a second pivotable structure, a first reflective element, a second reflective element, a light source, and a light receiving device. The light source and the light receiving device are remotely located from the reflective elements via the pivotable structures, and only the reflective elements and a portion of the pivotable structure are positioned adjacent the surface of an optical storage medium. High-capacity optical read/write devices and systems comprising these high-capacity pick-up mechanisms are also disclosed.

62 Claims, 22 Drawing Sheets



Prior Art

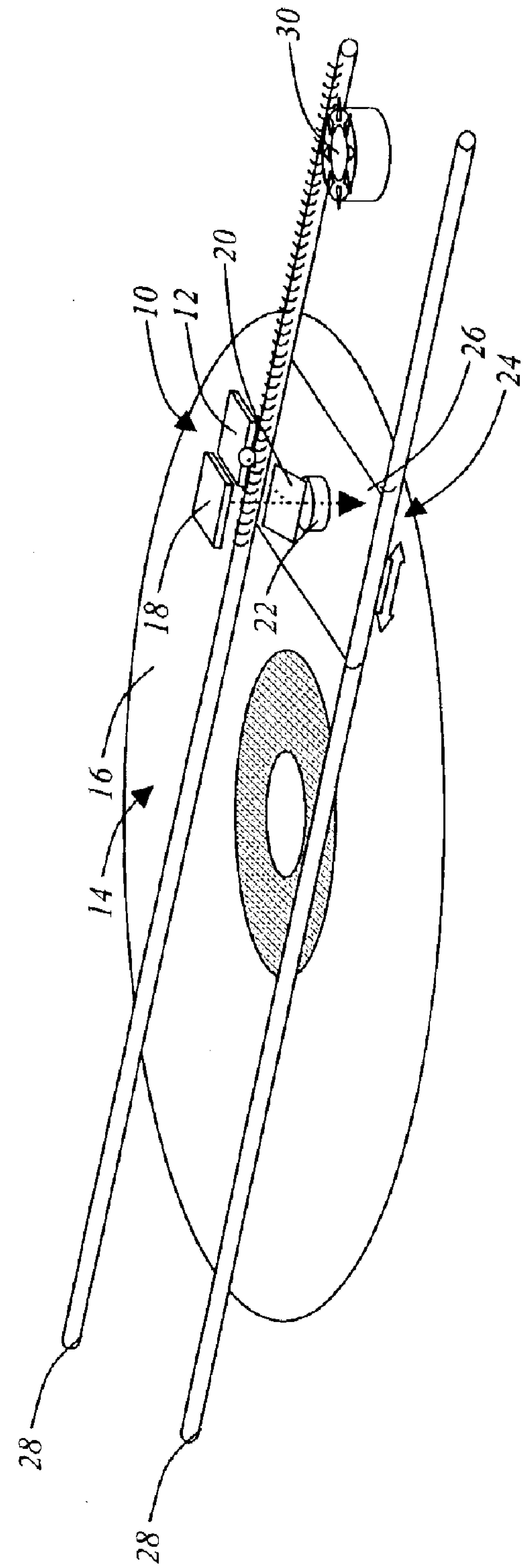


FIG. 1.

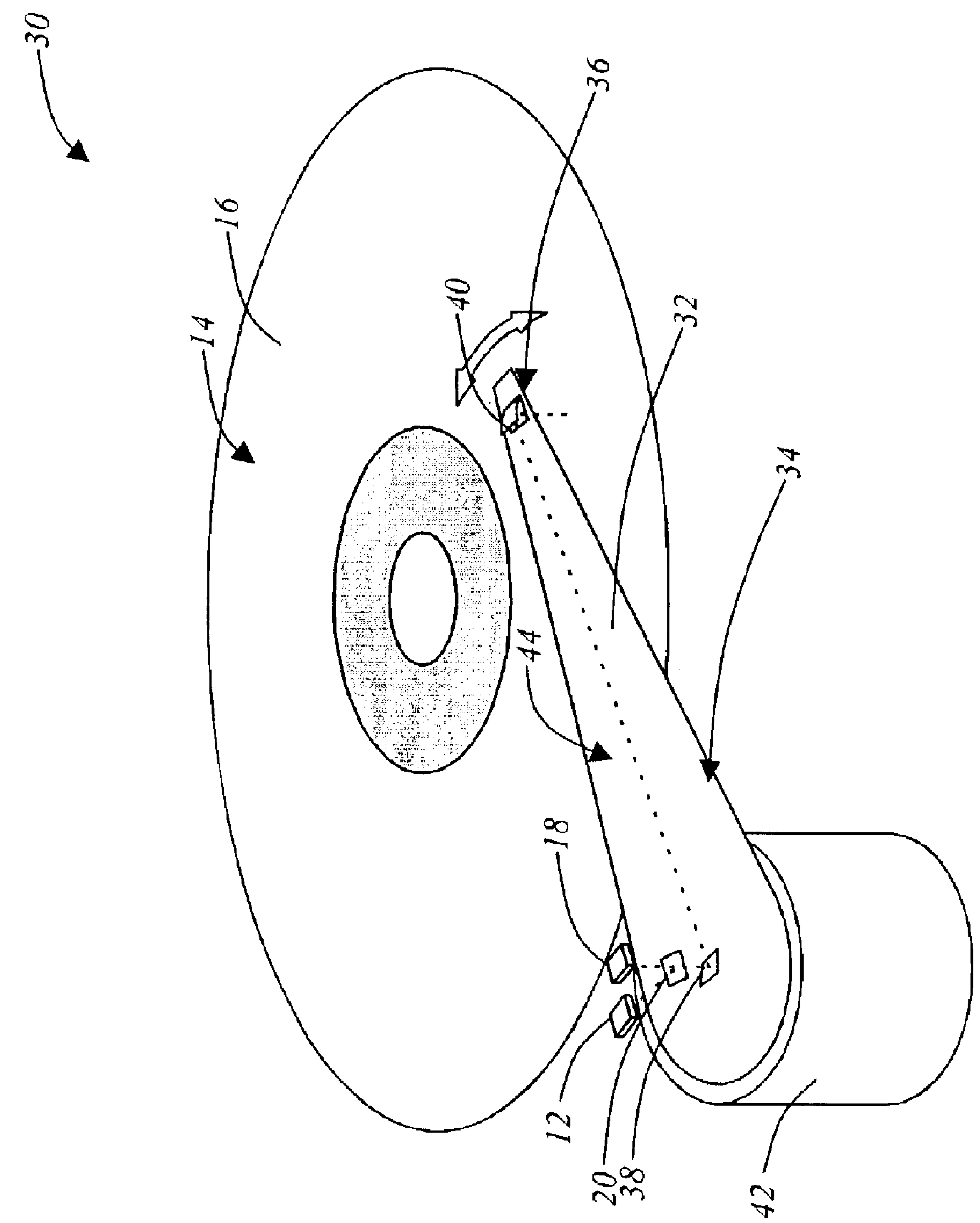


FIG. 2.

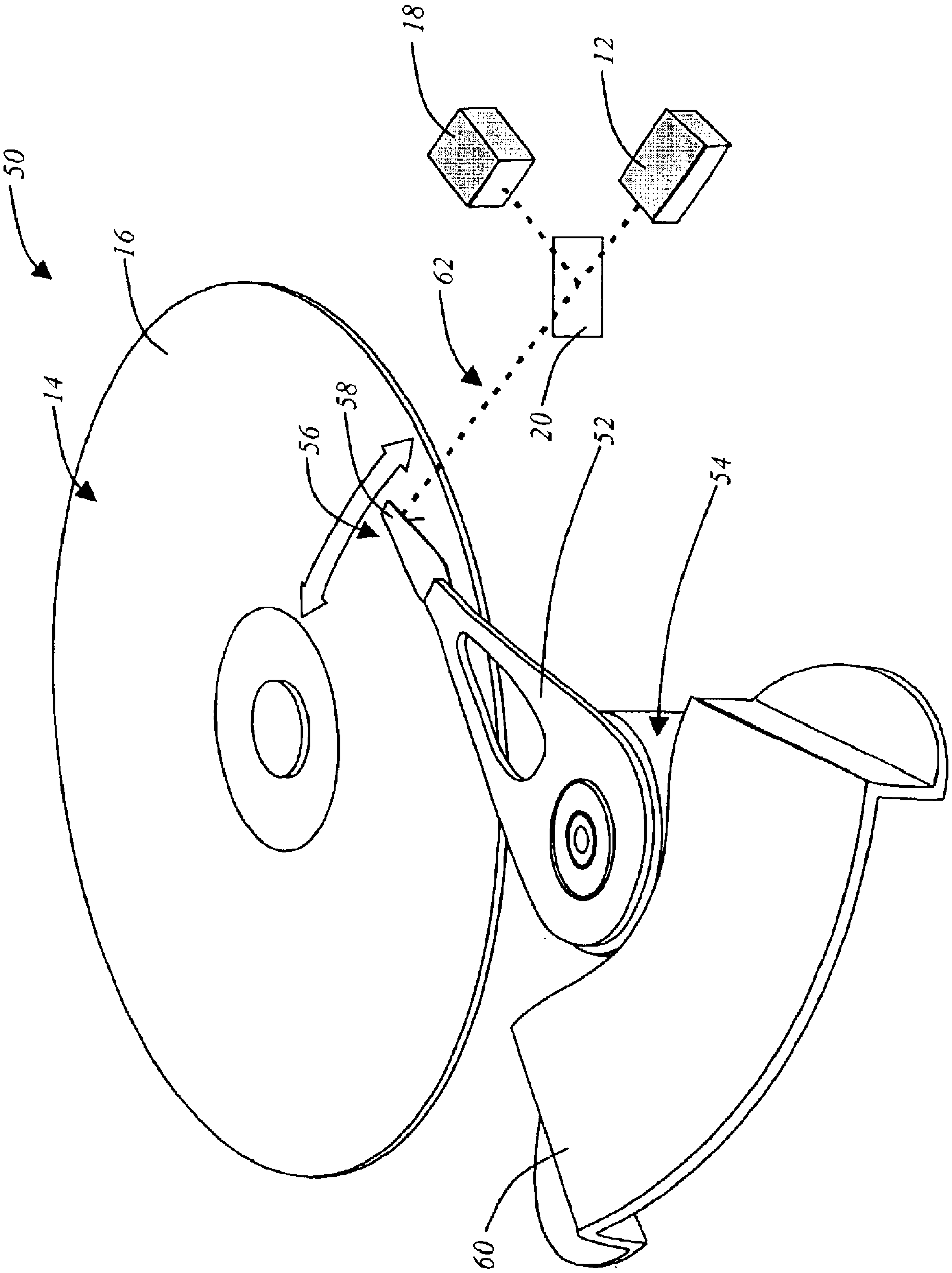


FIG. 3.

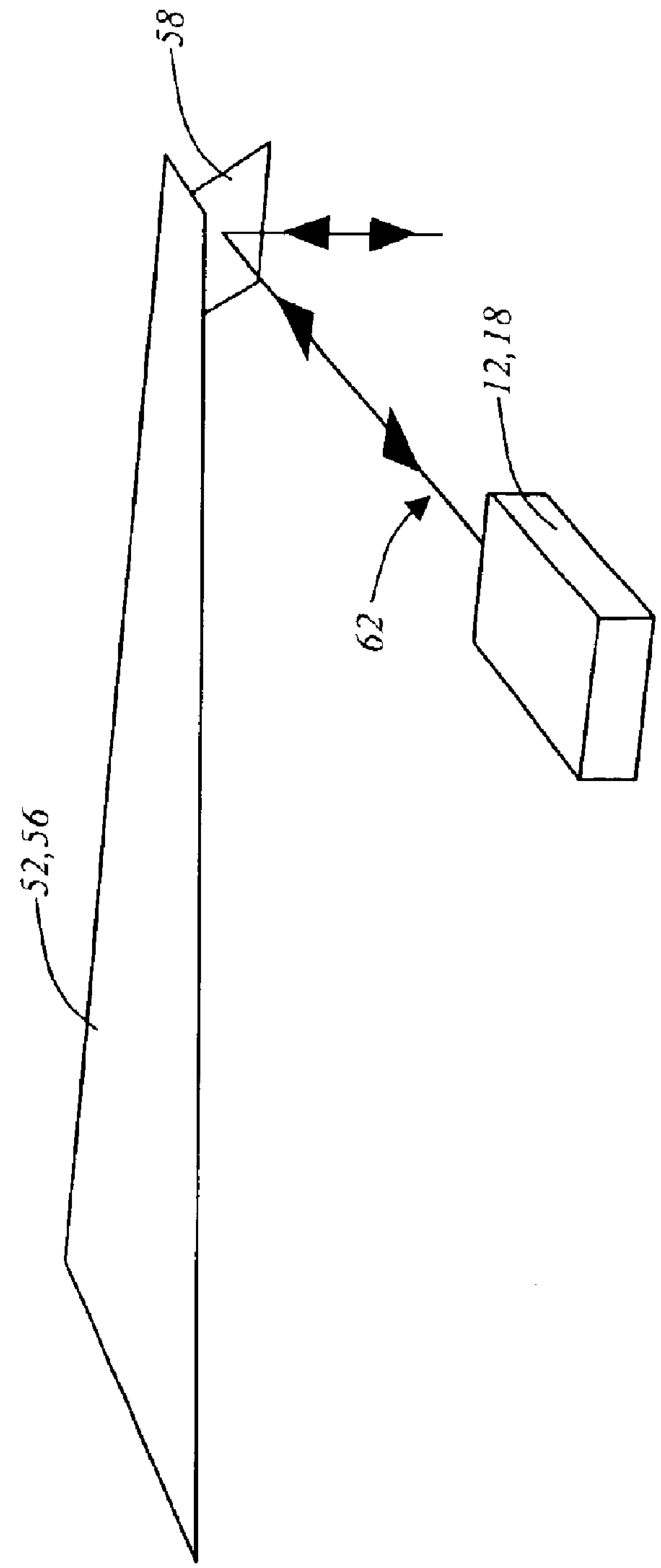


FIG. 4.

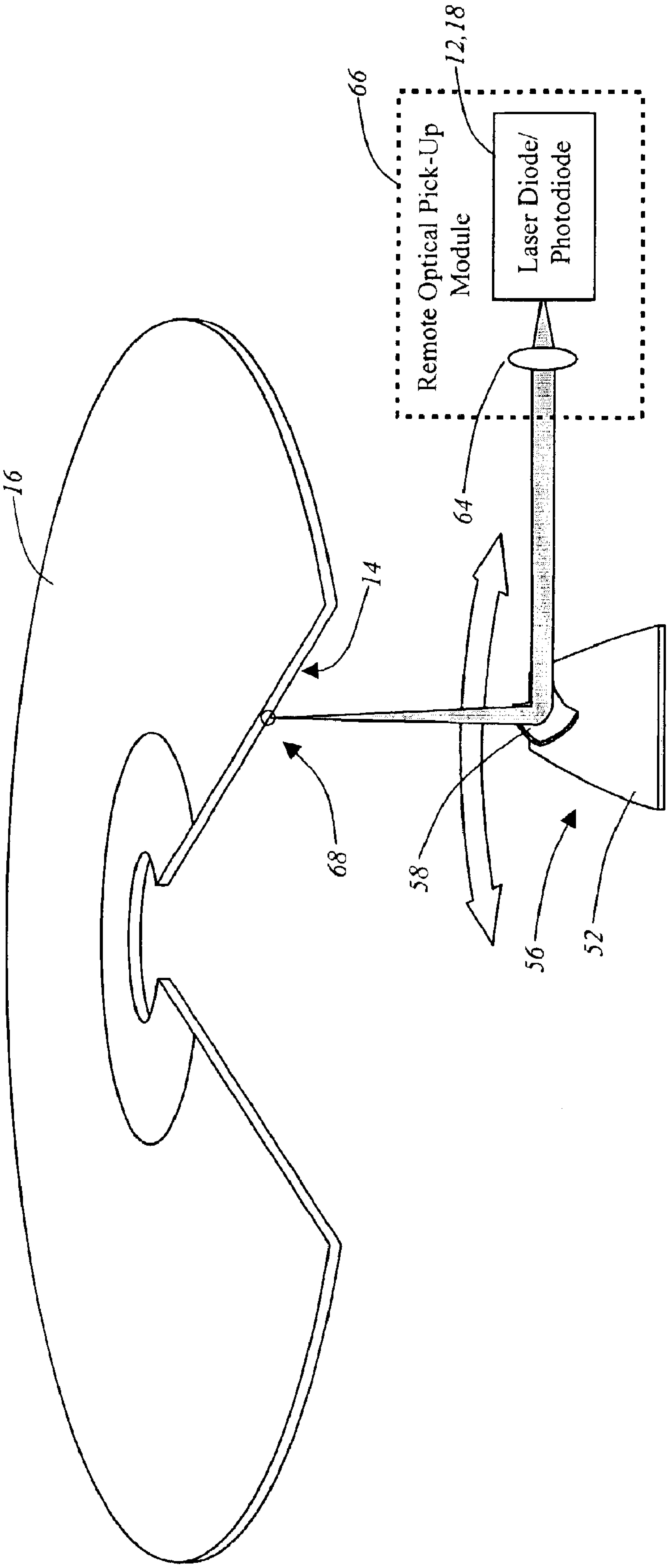

66
12,18
Remote Optical Pick-Up Module
Laser Diode/ Photodiode
16
64
14
68
58
56
52

FIG. 5.

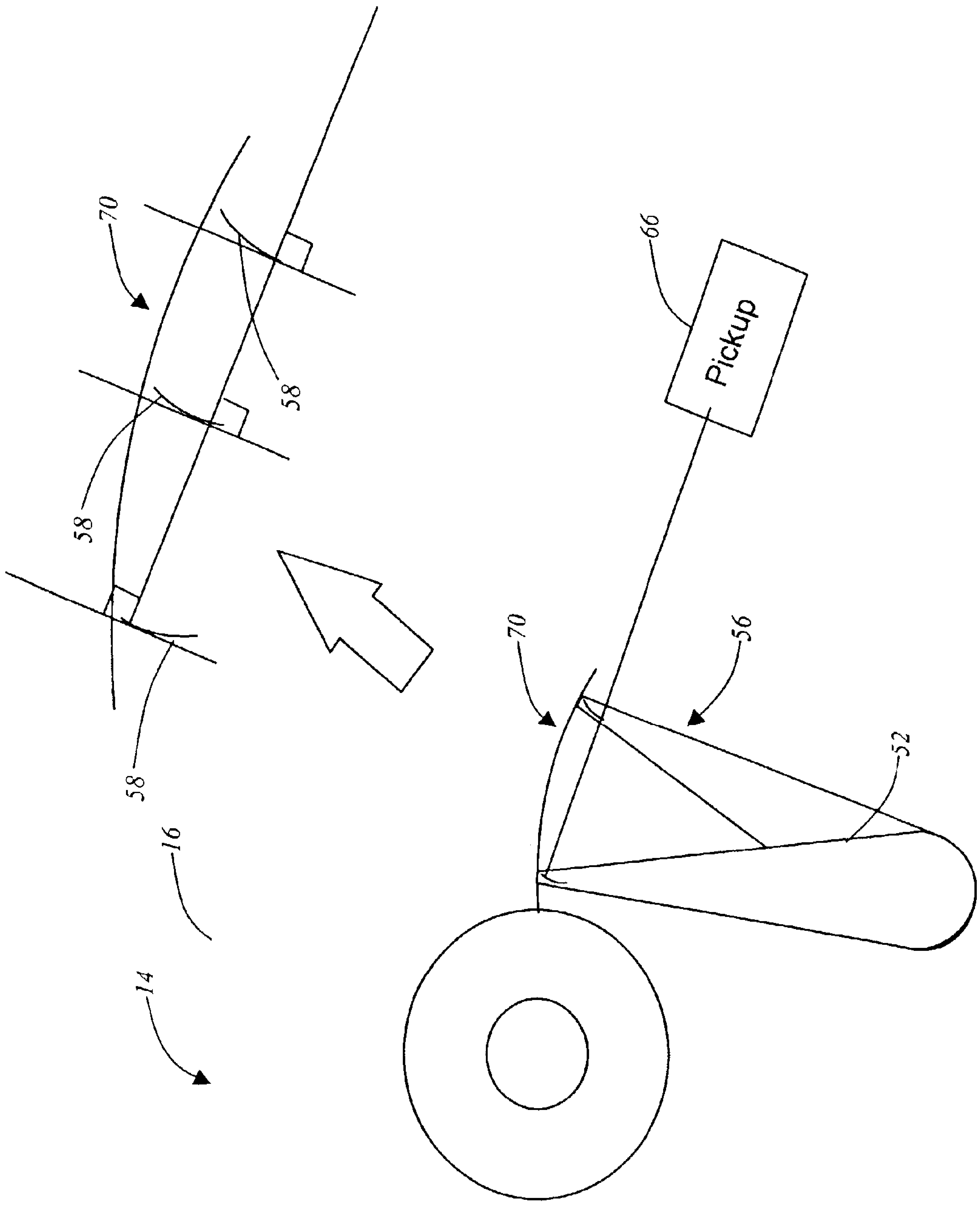


FIG. 6.

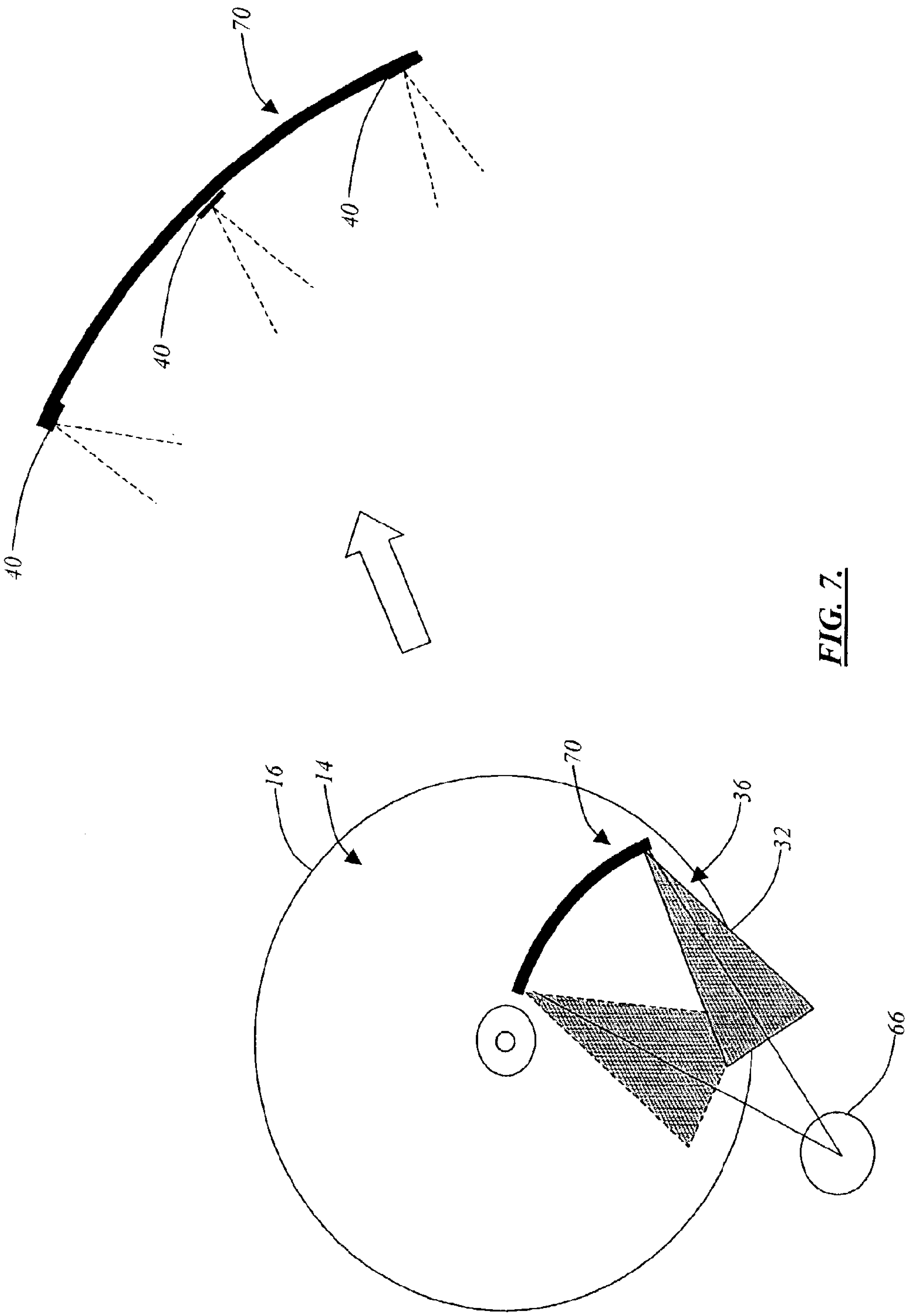
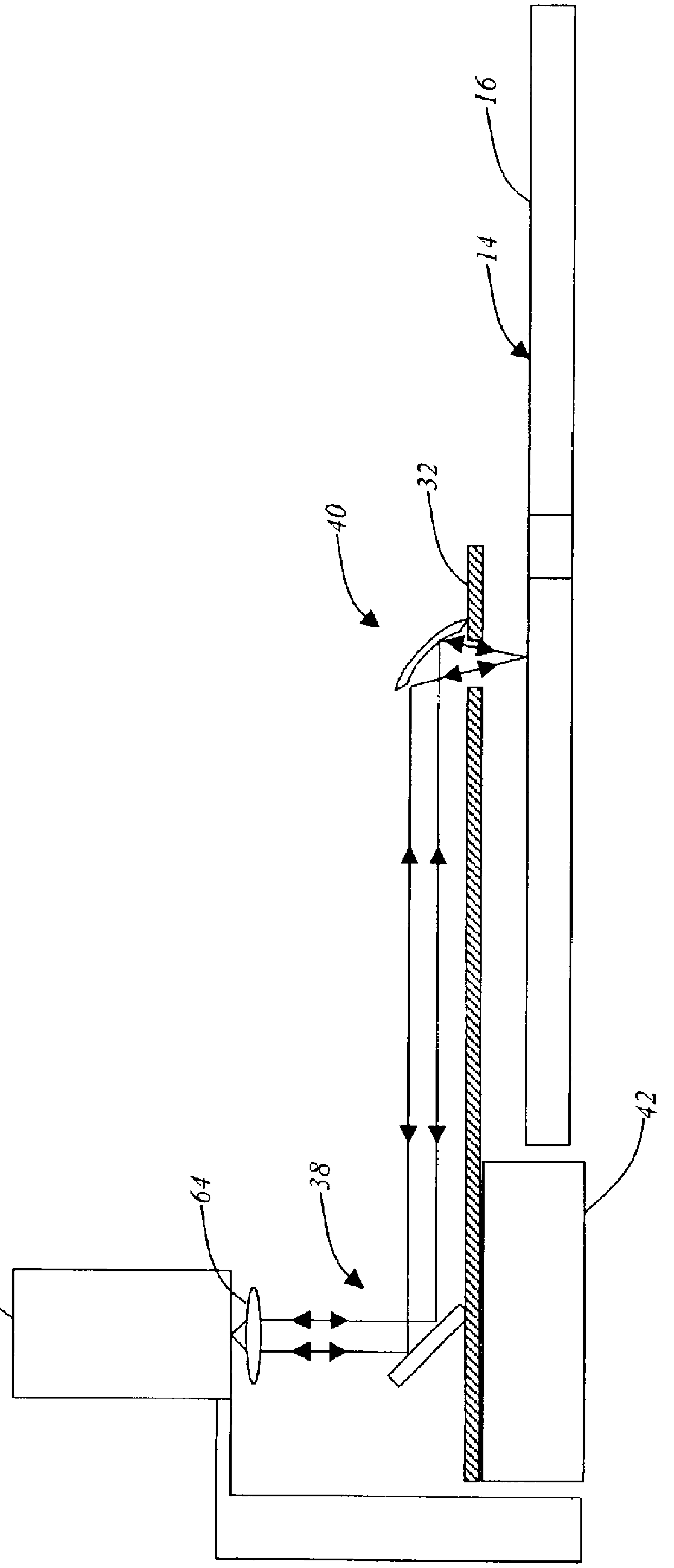


FIG. 7.



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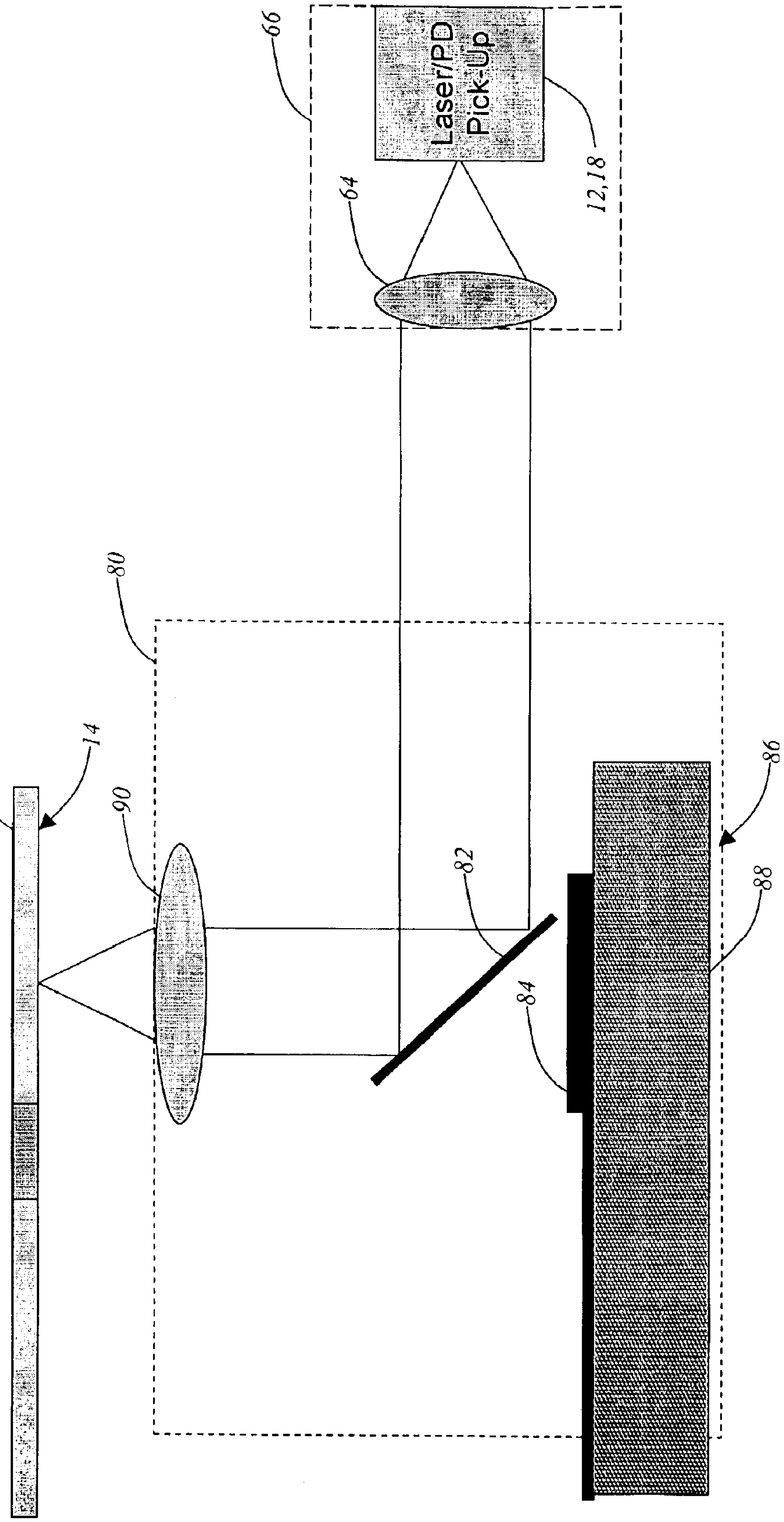


FIG. 9.

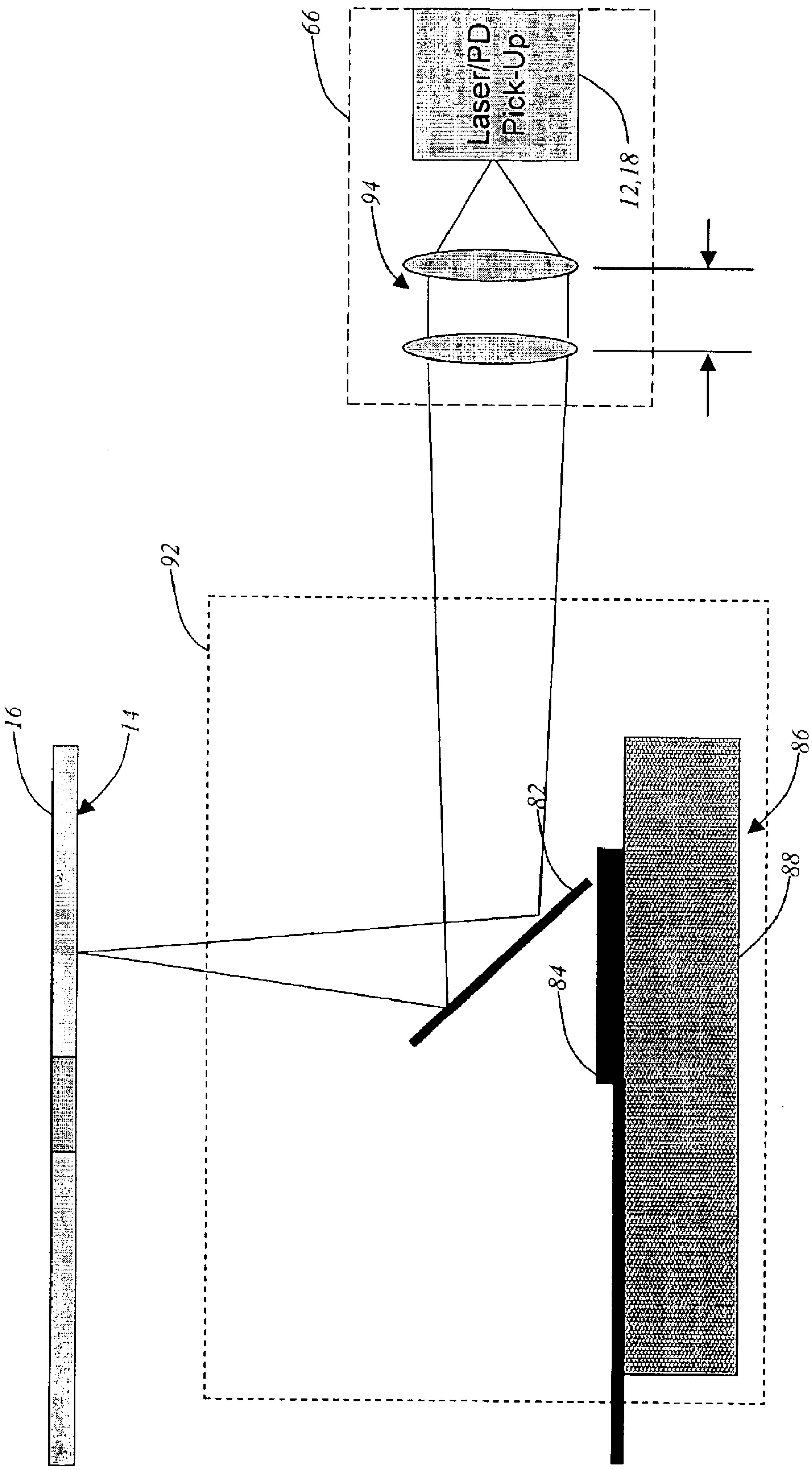


FIG. 10.

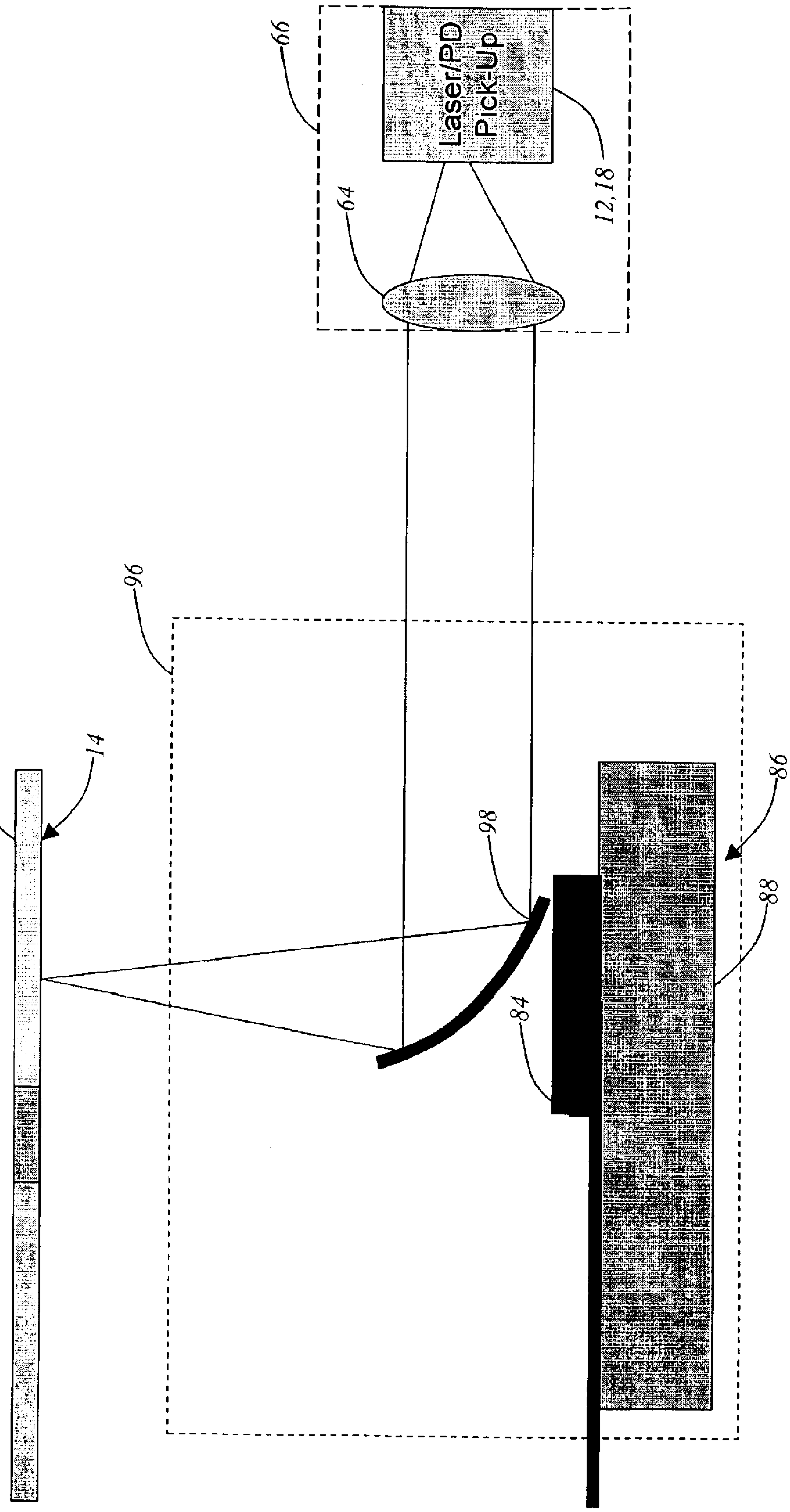


FIG. 11.

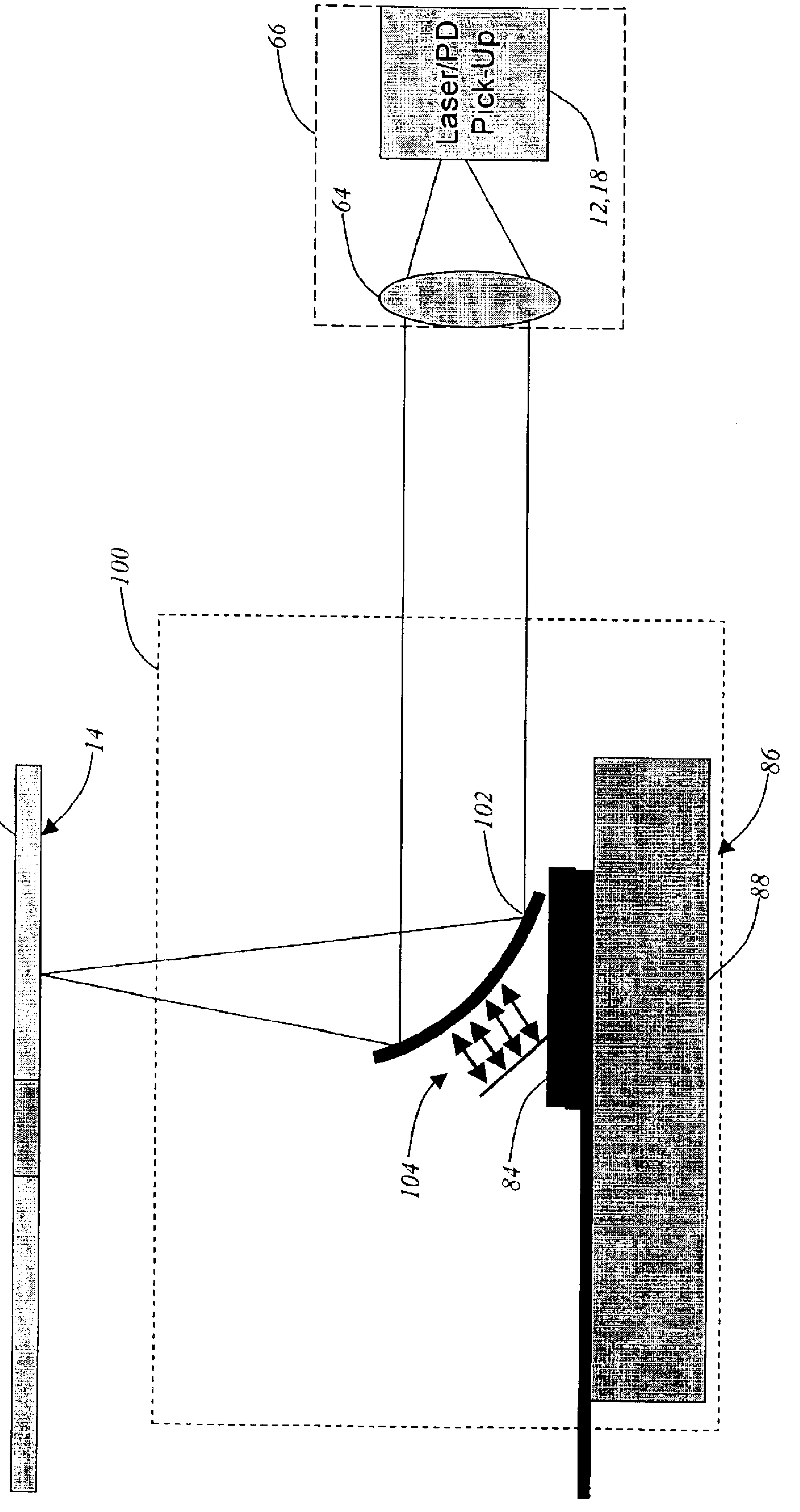


FIG. 12.

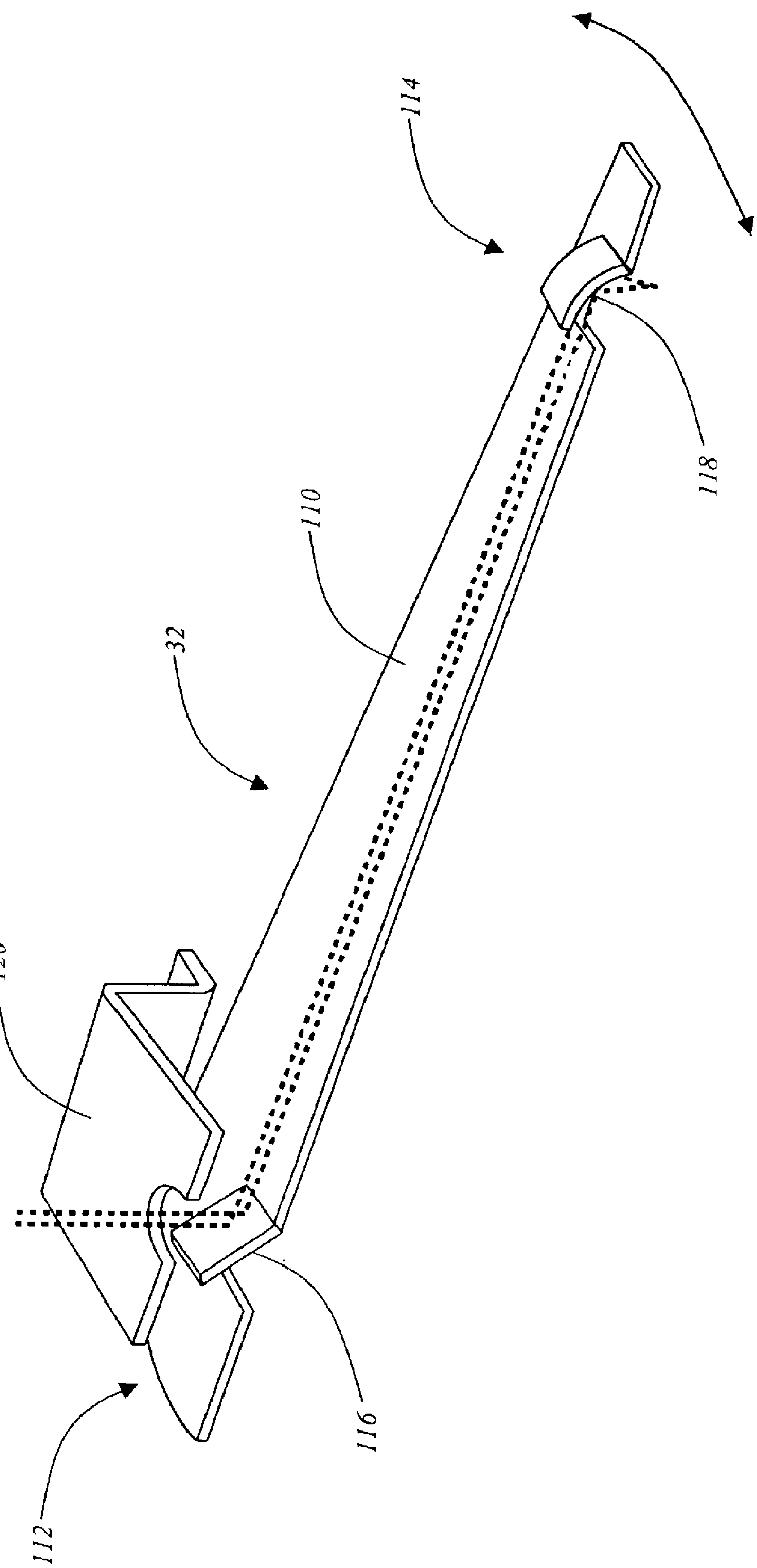
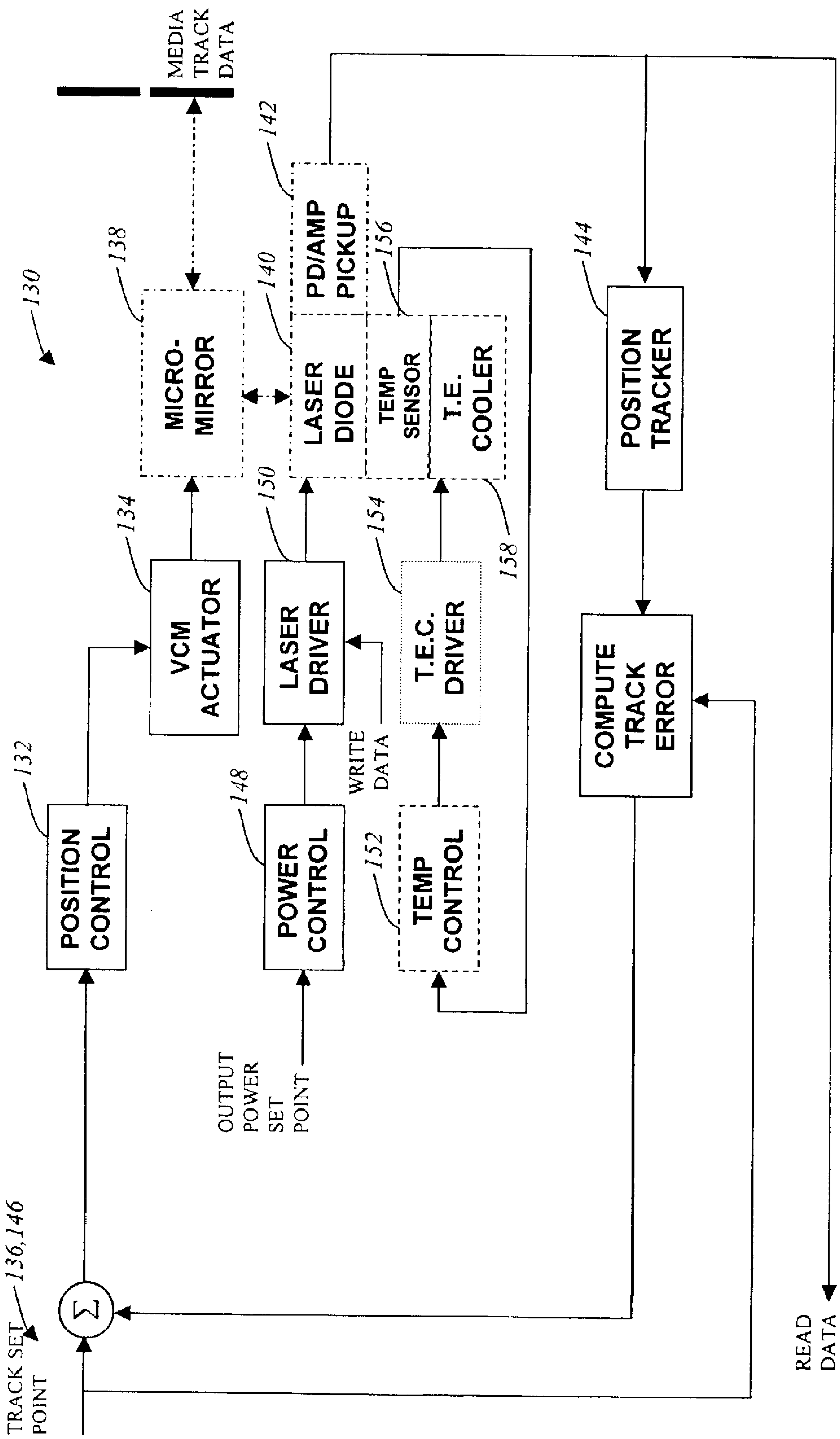


FIG. 13.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MEDIA TRACK DATA
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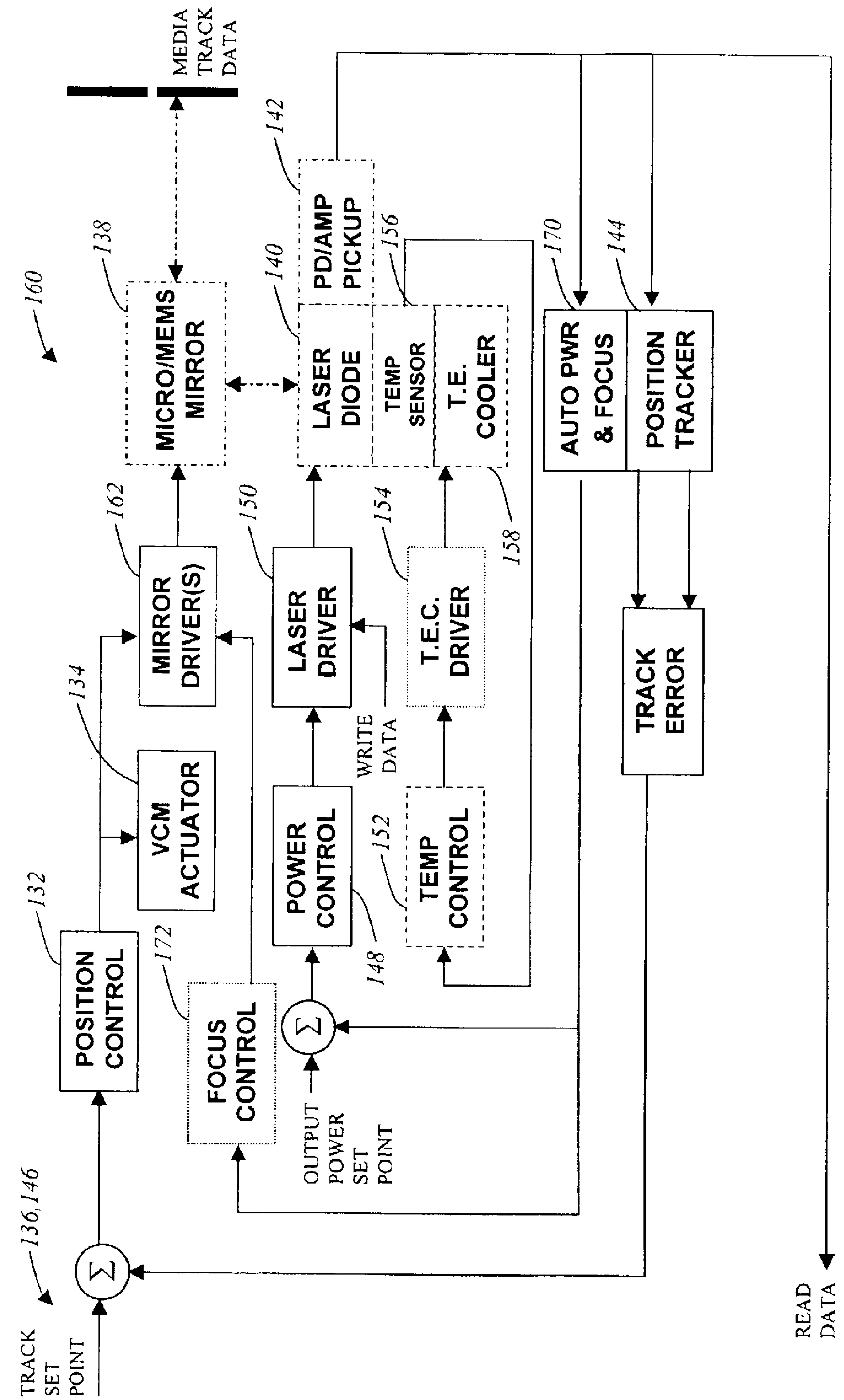
MICRO-MIRROR
142
PD/AMP PICKUP
140
LASER DIODE
156
TEMP SENSOR
T.E. COOLER
144
POSITION TRACKER
134
VCM ACTUATOR
150
LASER DRIVER
154
T.E.C. DRIVER
158
COMPUTE TRACK ERROR
132
POSITION CONTROL
148
POWER CONTROL
WRITE DATA
152
TEMP CONTROL
OUTPUT POWER SET POINT
136,146
Σ
TRACK SET POINT
READ DATA

FIG. 14.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138
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142
PD/AMP PICKUP
140
LASER DIODE
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TEMP SENSOR
T.E. COOLER
170
AUTO PWR & FOCUS
144
POSITION TRACKER
162
MIRROR DRIVER(S)
150
LASER DRIVER
154
T.E.C. DRIVER
158
WRITE DATA
TRACK ERROR
134
VCM ACTUATOR
POWER CONTROL
152
TEMP CONTROL
148
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POSITION CONTROL
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FOCUS CONTROL
Σ
OUTPUT POWER SET POINT
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Σ
TRACK SET POINT
READ DATA

FIG. 15.

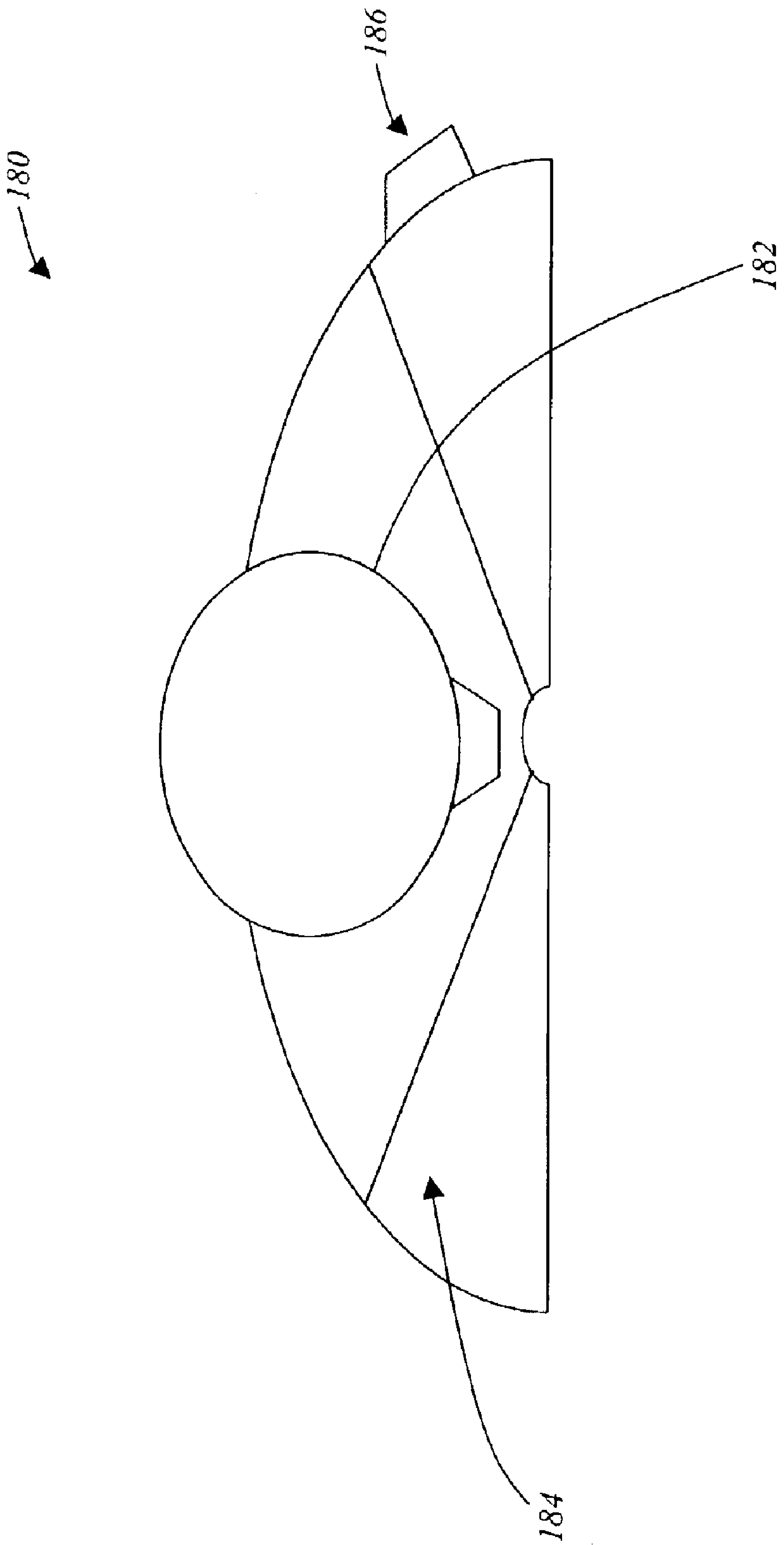

FIG. 16.

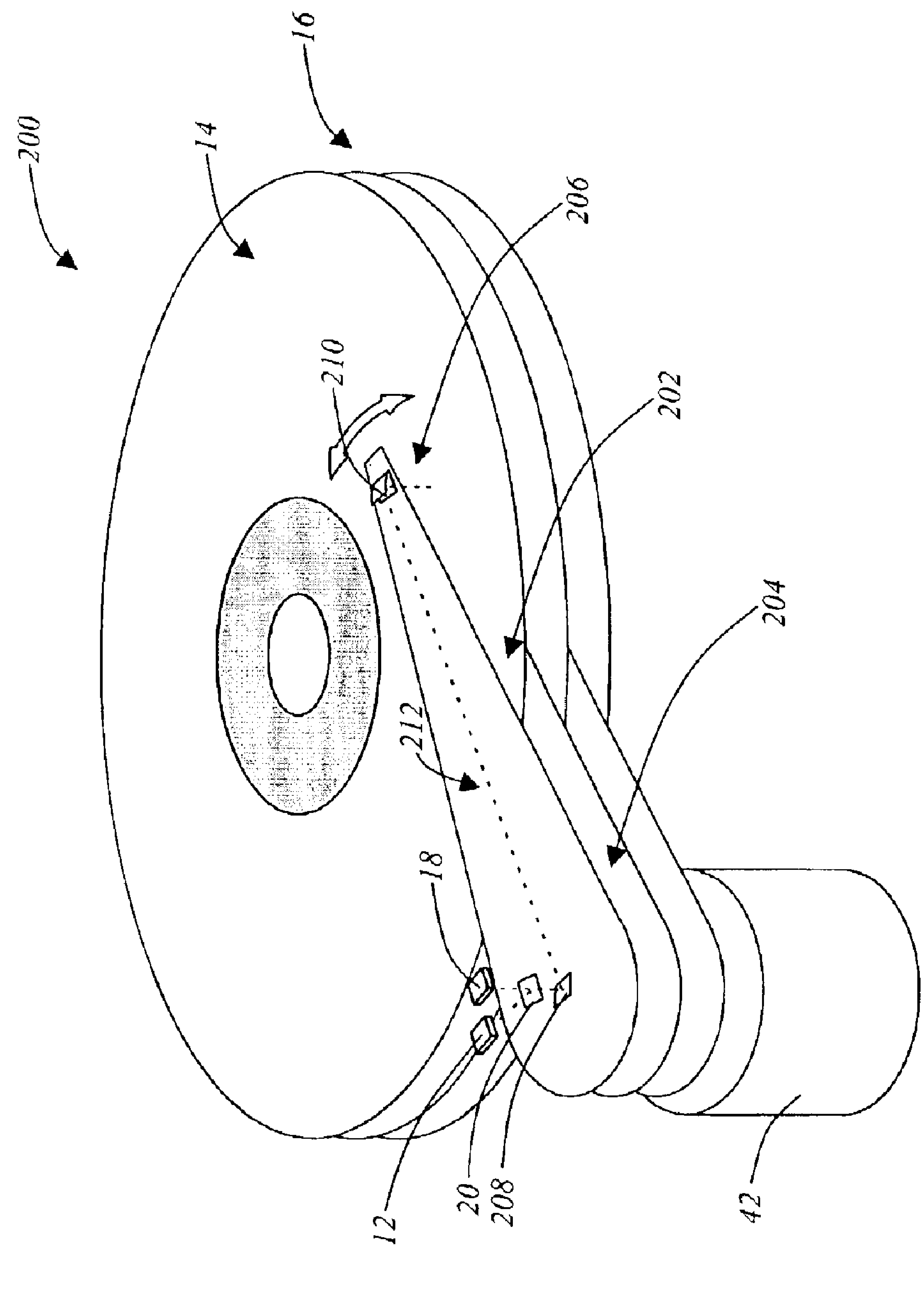

FIG. 17.

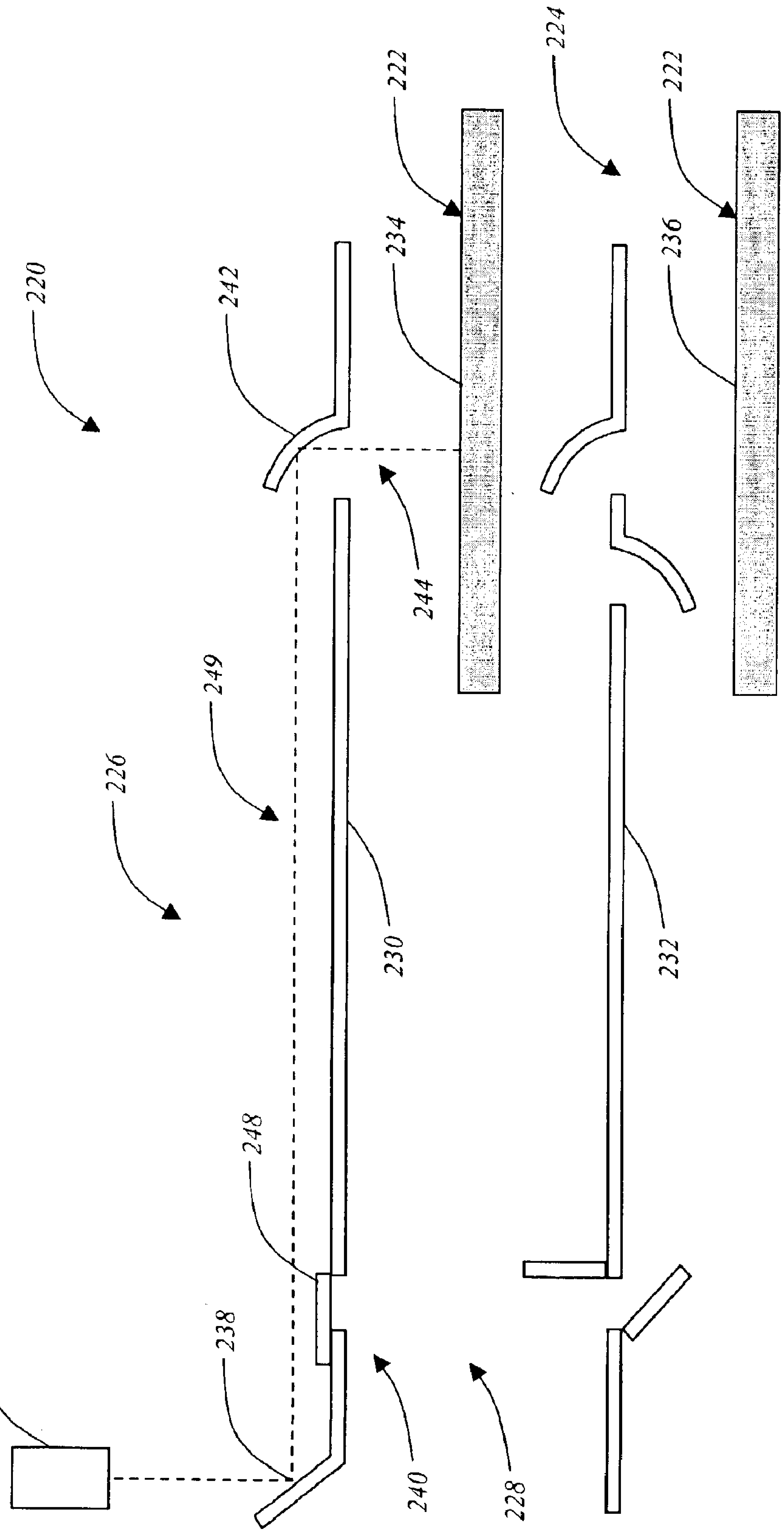

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FIG. 18.

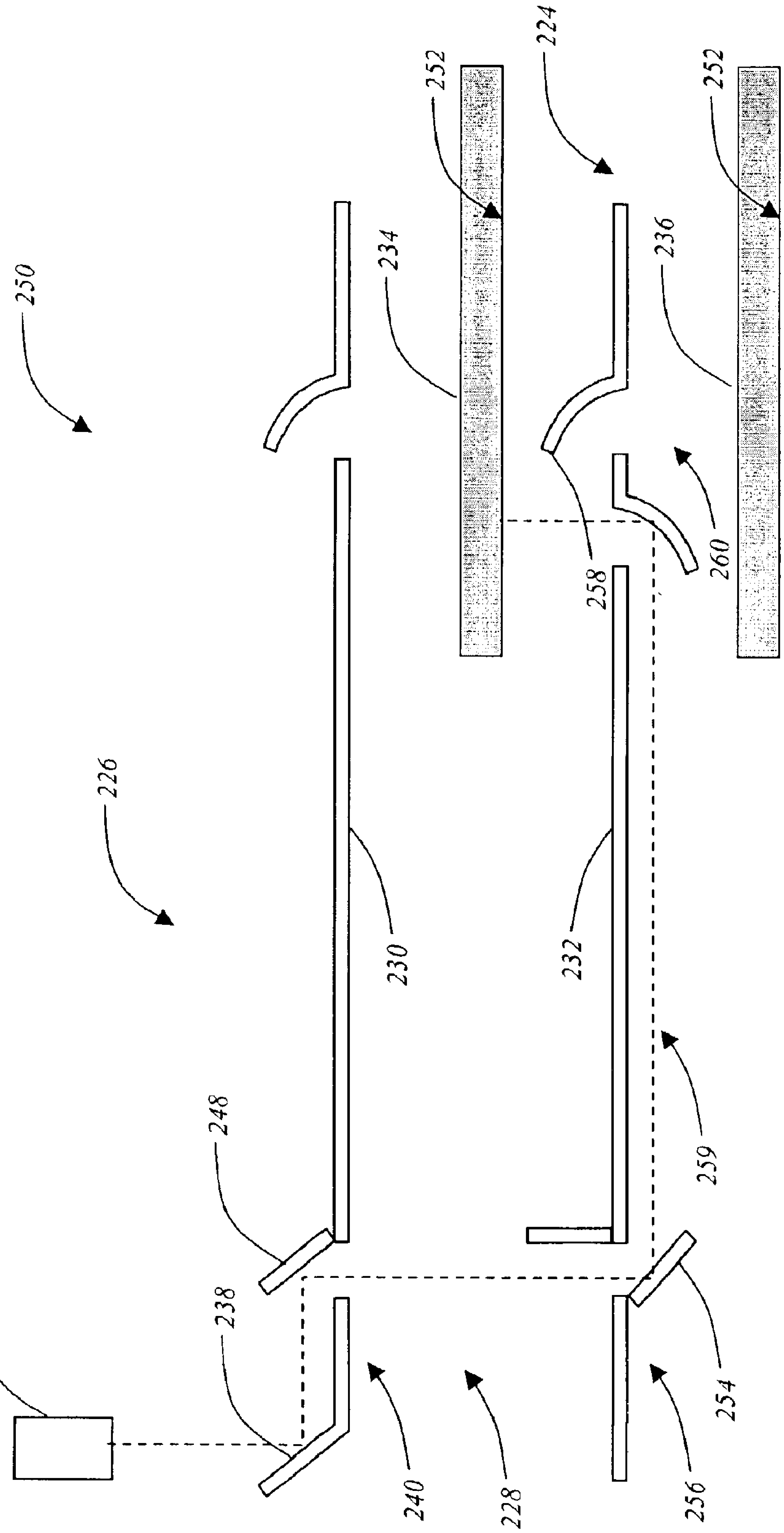
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FIG. 19.

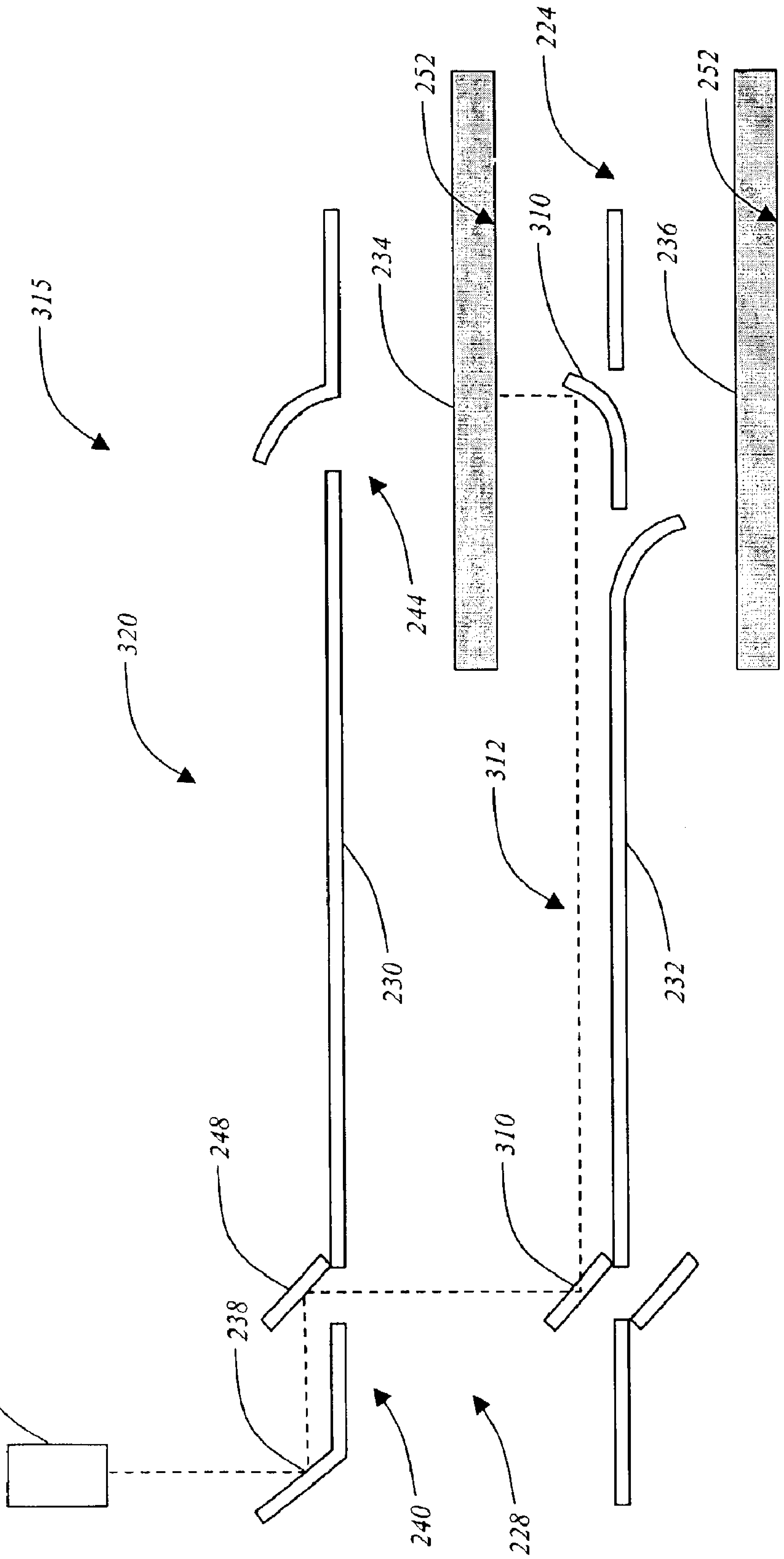
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FIG. 20.

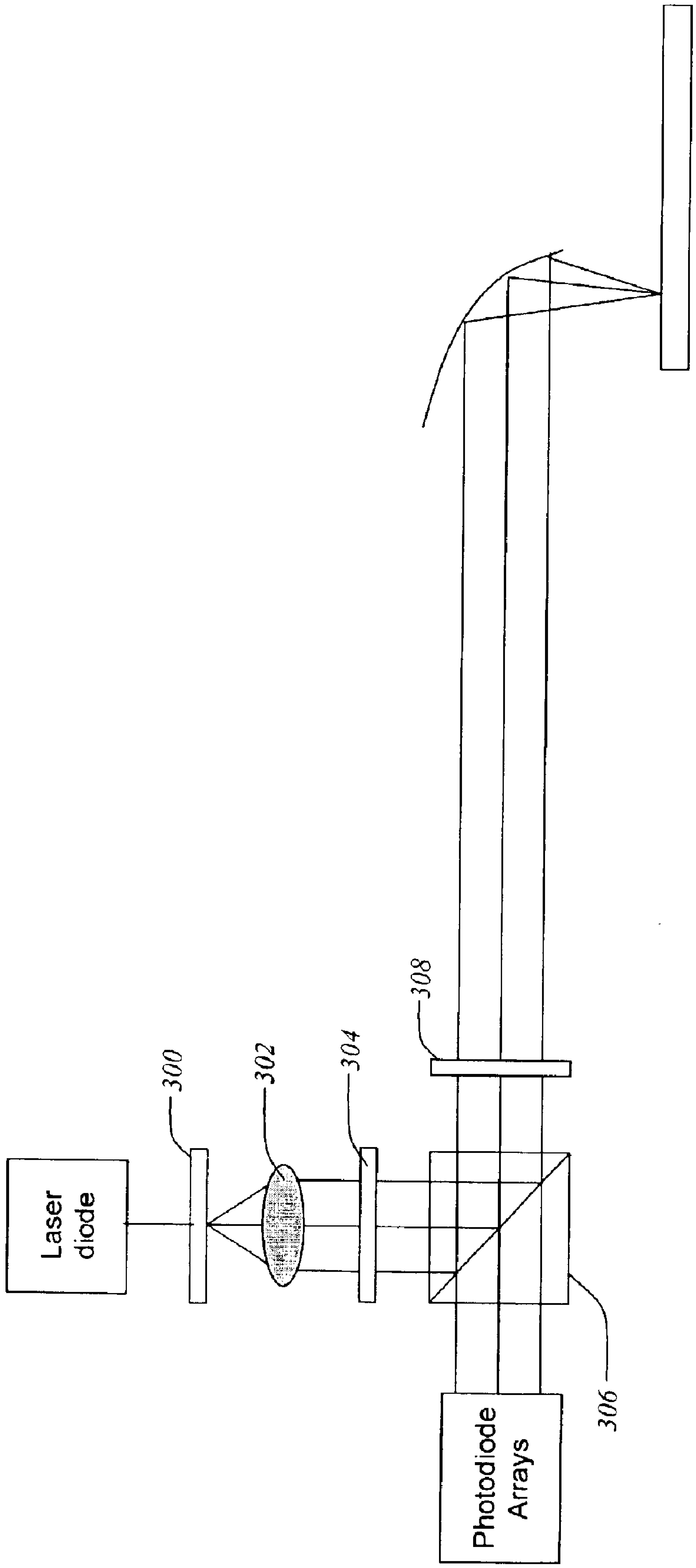

FIG. 21.

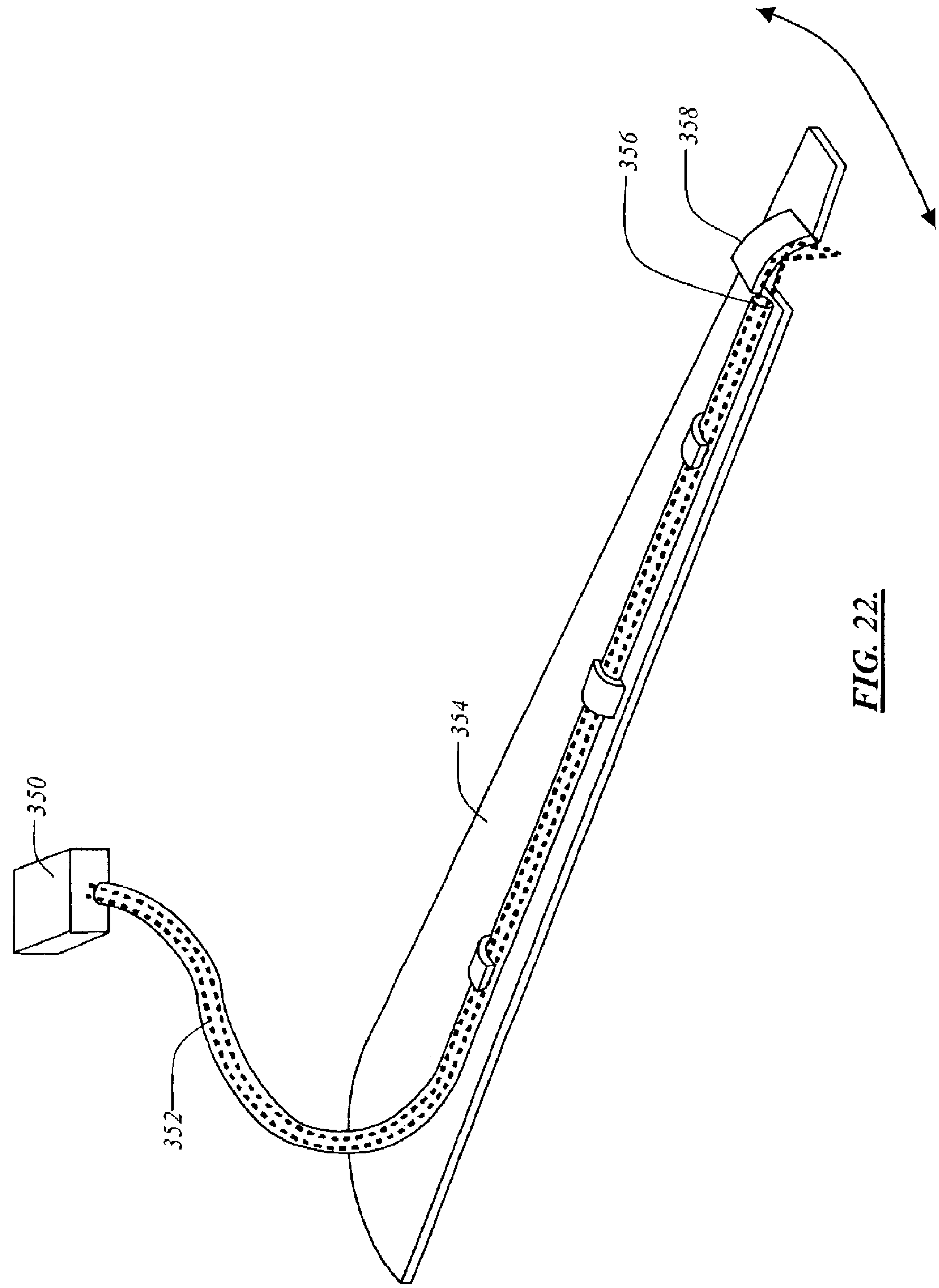

FIG. 22.

HIGH-CAPACITY OPTICAL READ/WRITE PICK-UP MECHANISM AND ASSOCIATED METHODS

FIELD OF THE INVENTION

The present invention relates generally to the field of optical read/write and optical storage media technology. More specifically, the present invention relates to high-speed, high-capacity optical read/write pick-up mechanisms that incorporate a light source and a light receiving device remotely located from a reflective element via a pivotable structure. Only the reflective element and a portion of the pivotable structure are positioned adjacent to the surface of an optical storage medium.

BACKGROUND OF THE INVENTION

Conventional optical read/write pick-up mechanisms, such as those used in compact disc ("CD") players/recorders, digital versatile disc ("DVD") players/recorders, and the like, incorporate a relatively heavy, bulky optical read/write head attached to a tracking mechanism. Typically, both the optical read/write head and the tracking mechanism are positioned adjacent to the surface of a spinning optical storage medium, such as a CD, a DVD, or the like, during operation. This configuration is illustrated in FIG. **1**. Referring to FIG. **1**, the optical read/write head **10** includes a light source **12**, such as a laser diode or the like, operable for transmitting encoded/un-encoded light, such as laser light or the like, to the surface **14** of the optical storage medium **16**. The optical read/write head **10** also includes a light receiving device **18**, such as a photodiode or the like, operable for receiving encoded/un-encoded light, such as laser light or the like, from the surface **14** of the optical storage medium **16**. A reflective element **20**, such as a semi-reflective mirror, a beam splitter, or the like, and a focusing lens **22** or other focusing optics may also be used to transmit the light to and/or receive the light from the surface **14** of the optical storage medium **16**.

Using the optical read/write head **10**, data may be retrieved from and/or stored on predetermined portions of the surface **14** of the optical storage medium **16** via the selective positioning of the tracking mechanism **24** and the optical read/write head **10**. Typically, the tracking mechanism **24** includes a pick-up carrier assembly **26** movably attached to one or more guide rails **28**, a portion of which may be threaded. In conjunction with a stepper motor **30** or the like, the one or more guide rails **28** are operable for moving the tracking mechanism **24** and the optical read/write head **10** linearly with respect to the surface **14** of the optical storage medium **16**. Alternatively, a typical CD player/recorder may use the tracks of a CD for position control, rather than an encoder embedded in the rail, to reduce cost.

As described above, conventional optical read/write heads are relatively heavy and bulky (due to the need for a laser diode, a photodiode, focusing optics, etc.). Conventional optical read/write heads are also positioned adjacent to the surface of the optical storage medium along with a tracking mechanism. Conventional optical read/write heads are further limited to linear movement with respect to the surface of the optical storage medium. As a result, the current generation of optical read/write pick-up mechanisms has a relatively slow access time, especially when compared to that of conventional magnetic storage devices. For example, the average random access time of a CD player/recorder, a

DVD player/recorder, or the like is about 100 ms. A magnetic hard drive, however, has an average random access time of about 5–10 ms. This difference in average random access time is attributable to the fact that a magnetic read/write head is relatively light and small, and may be attached to a relatively fast-moving voice coiled motor or other servo mechanism that may be moved back and forth across a magnetic platter at speeds of up to about 60 times per second. The relatively heavy, bulky optical read/write head, mounted on a linear track and controlled by a servo motor or the like, may only be moved back and forth across the optical disc at speeds of about 5–10 times per second. As a result, for many applications, a magnetic storage device is preferred. For example, many computerized game systems and the like use a magnetic storage device to run graphics-intensive applications and to store data, and an optical storage device to run other applications, such as game programs. This is due to the high speed and capacity requirements associated with such graphics and storage applications.

Recent efforts related to CD player/recorders, DVD players/recorders, and the like have focused on improving the data transfer rate by increasing the rotational speed of the spinning optical storage medium. These efforts, although marginally effective in increasing the maximum data transfer rate, do little to improve the average random access time of the drives or their capacity. Attempts to increase the capacity of optical storage media and optical storage devices have focused on combining optical and magnetic technologies. For example, "near-field recording" requires the optical read/write head to be positioned very close to the surface of the optical storage medium. Such high-density digital disc ("HDD")-related attempts have failed due to the short working distances between the read/write head and the storage medium, contamination on the surface of the medium substantially affecting the read/write pick-up mechanism.

Thus, what is still needed is a high-speed, high-capacity optical read/write pick-up mechanism that, in various respects, may be used effectively with at least the prior two generations of optical storage media. The present invention seeks to divorce the relatively heavy, bulky portion of the optical read/write head described above from the actuation/tracking mechanism and, using free space optics and/or guided optics, replace it with a microstructure mirror, a moveable micro-electromechanical systems ("MEMS") mirror, or the like. As a result, the weight and size of the optical read/write pick-up mechanism may be drastically reduced, especially over the surface of the optical storage medium, and the performance of the optical storage device is allowed to approach that of a magnetic storage device.

Additionally, the configuration of the optical read/write pick-up mechanism of the present invention makes it practical to read from and/or write to both surfaces of an optical storage medium, thereby increasing capacity. Finally, the use of a voice coil motor or the like, such as that used in magnetic storage devices, for the actuation and control of the reflective element makes the optical read/write pick-up mechanism of the present invention economically efficient and commercially viable.

BRIEF SUMMARY OF THE INVENTION

As described above, an optical storage medium, such as a compact disc ("CD"), a digital versatile disc ("DVD"), or the like, contains tracks of data that are read from and/or written to by an optical read/write pick-up mechanism. The actuation/tracking mechanism associated with the optical read/write pick-up mechanism must have relatively low weight and small size in order to seek selected tracks of data with low latency and high access times. Advantageously, the optical read/write pick-up mechanism of the present invention replaces the relatively heavy, bulky optical read/write head (including the light source, the light receiving device, the reflective element, the focusing lens, etc.), comprising a portion of a conventional optical read/write pick-up mechanism and attached to the actuation/tracking mechanism, with a relatively simple reflective element. This reflective element may include a microstructure mirror, a movable microelectromechanical systems ("MEMS") mirror, or the like. This allows the actuation/tracking mechanism to move with increased speed relative to the surface of the optical storage medium. The relatively heavy, bulky components of the optical read/write head are located remotely from the microstructure mirror, the MEMS mirror, or the like and interact with the microstructure mirror, the MEMS mirror, or the like via free space optics and/or guided optics. Advantageously, the configuration of the optical read/write pick-up mechanism of the present invention allows both surfaces of the optical storage medium to be read from and/or written to and a stronger light source may be used, if desired.

In one embodiment of the present invention, a high-capacity pick-up mechanism operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media includes a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium. The pick-up mechanism also includes a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium. The pick-up mechanism further includes a first reflective element associated with the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium, and a second reflective element associated with the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium. The pick-up mechanism still further includes a light source associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path. The pick-up mechanism still further includes a light receiving device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path.

In another embodiment of the present invention, a high-capacity optical pick-up mechanism operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media includes a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium. The optical pick-up mechanism also includes a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a second optical storage medium. The optical pick-up mechanism further includes a first reflective element associated with the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium, a second reflective element associated with the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium, and a third reflective element associated with the second end of the second pivotable structure, wherein the third reflective element is operable for transmitting light to and/or receiving light from the top surface of the second optical storage medium. The optical pick-up mechanism still further includes a light source associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path, and wherein the light source is operable for transmitting light to the third reflective element along a third optical path. The optical pick-up mechanism still further includes a light receiving device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path, and wherein the light receiving device is operable for receiving light from the third reflective element along the third optical path.

In a further embodiment of the present invention, a high-capacity method for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media includes providing a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium. The method also includes providing a second pivotable having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium. The method further includes disposing a first reflective element in proximity to the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium, and disposing a second reflective element associated in proximity to the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium. The method still further includes disposing a light source in proximity to both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path. The method still further includes disposing a light receiving device in proximity to both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path.

Advantageously, the optical read/write pick-up mechanism of the present invention uses a remote laser source and photo-detection opto-electronics to provide relatively fast seek/access times with relatively low track-to-track latency. This is desirable for time-sensitive applications, such as graphics applications, imaging applications, and storage applications, where data transfer rates and seek/access times are critical performance criteria.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional optical read/write pick-up mechanism, including a conventional optical read/write head positioned adjacent to the surface of a spinning optical storage medium;

FIG. **2** is a perspective view of one embodiment of the high-speed optical read/write pick-up mechanism of the present invention;

FIG. **3** is a perspective view of another embodiment of the high-speed optical read/write pick-up mechanism of the present invention;

FIG. **4** is a schematic diagram illustrating the optical path formed and used by the optical read/write pick-up mechanism of the present invention;

FIG. **5** is a perspective view/schematic diagram illustrating one embodiment of a reflective element that may be used in conjunction with the optical read/write pick-up mechanism of the present invention;

FIG. **6** is a schematic diagram illustrating a first plurality of possible configurations of the reflective element of the optical read/write pick-up mechanism of the present invention;

FIG. **7** is a schematic diagram illustrating a second plurality of possible configurations of the reflective element of the optical read/write pick-up mechanism of the present invention;

FIG. **8** is a cross-sectional side view of one embodiment of an optical read/write pick-up mechanism suitable for use with the reflective element configuration of FIG. **7**;

FIG. **9** is a cross-sectional side view of a further embodiment of the optical read/write pick-up mechanism of the present invention, including a movable/deformable reflective element;

FIG. **10** is a cross-sectional side view of a still further embodiment of the optical read/write pick-up mechanism of the present invention, including a movable/deformable reflective element;

FIG. **11** is a cross-sectional side view of a still further embodiment of the optical read/write pick-up mechanism of the present invention, including a movable/deformable reflective element;

FIG. **12** is a cross-sectional side view of a still further embodiment of the optical read/write pick-up mechanism of the present invention, including a movable/deformable reflective element;

FIG. **13** is a perspective view of one embodiment of a pivotable structure and mounting bracket that may be used in conjunction with the optical read/write pick-up mechanism of the present invention;

FIG. **14** is a schematic control diagram illustrating one embodiment of an optical media system that may be associated with and use the optical read/write pick-up mechanism of the present invention;

FIG. **15** is a schematic control diagram illustrating another embodiment of an optical media system that may be associated with and use the optical read/write pick-up mechanism of the present invention;

FIG. **16** is a perspective view of one embodiment of a moveable micro-electromechanical systems ("MEMS") mirror system that may be used in conjunction with the optical read/write pick-up mechanism of the present invention;

FIG. **17** is a perspective view of one embodiment of the high-capacity optical read/write pick-up mechanism of the present invention;

FIG. **18** is a schematic diagram illustrating another embodiment of the high-capacity optical read/write pick-up mechanism of the present invention, highlighting a first configuration suitable for reading data from and/or writing data to the top surface of one of a plurality of optical storage media;

FIG. **19** is a schematic diagram illustrating a further embodiment of the high-capacity optical read/write pick-up mechanism of the present invention, highlighting a second configuration suitable for reading data from and/or writing data to the bottom surface of one of a plurality of optical storage media;

FIG. **20** is a schematic diagram illustrating a still further embodiment of the high-capacity optical read/write pick-up mechanism of the present invention, highlighting a third configuration suitable for reading data from and/or writing data to the bottom surface of one of a plurality of optical storage media;

FIG. **21** is a schematic diagram illustrating a plurality of additional optical components that may be utilized in conjunction with the systems and methods of the present invention; and

FIG. **22** is a perspective view of one embodiment of the optical read/write pick-up mechanism of the present invention, incorporating guided optics.

DETAILED DESCRIPTION OF THE INVENTION

As described above, the optical read/write pick-up mechanism of the present invention replaces the relatively heavy, bulky optical read/write head, including the light source, the light receiving device, the reflective element, the focusing lens, etc., attached to the actuation/tracking mechanism of a conventional optical read/write pick-up mechanism with a relatively simple reflective element, such as a microstructure mirror, a moveable micro-electromechanical systems ("MEMS") mirror, or the like. This allows the actuation/tracking mechanism to move with increased speed with respect to the surface of an optical storage medium. The relatively heavy, bulky components of the optical read/write head are located remotely from the microstructure mirror, MEMS mirror, or the like and interact with the microstructure mirror, MEMS mirror, or the like via free space optics. The configuration of the optical read/write pick-up mechanism of the present invention allows both surfaces of the optical storage medium to be read from and/or written to and a stronger light source may be used.

Referring to FIG. **2**, in one embodiment of the present invention, a high-speed optical read/write pick-up mechanism **30** operable for reading data from and/or writing data to the surface **14** of an optical storage medium **16**, such as a compact disc ("CD"), a digital versatile disc ("DVD"), or the like, includes a pivotable structure **32**, such as a pivotable arm or the like, having a first end **34** and a second end **36**. A first reflective element **38**, such as a reflective mirror or the like, is attached to or integrally formed with the first end **34** of the pivotable structure **32**. A second reflective element **40** is attached to or integrally formed with the second end **36** of the pivotable structure **32**. The second end **36** of the pivotable structure **32** is positioned adjacent to and in a spaced-apart relationship with the surface **14** of the optical storage medium **16**. An actuation device **42**, such as a voice coil motor, a servo mechanism, or the like, is coupled to the first end **34** of the pivotable structure **32** and, when actuated, causes the second end **36** of the pivotable structure **32** to move in an arc, parallel to the surface **14** of the optical storage medium **16** while the optical storage medium **16** is spinning. Thus, the second reflective element **40** may be positioned adjacent to any selected portion of the surface **14** of the optical storage medium **16**.

A light source **12**, such as a laser diode or the like, and a semi-reflective mirror **20** are positioned in proximity to the first end of the pivotable structure **32** and the first reflective element **38**. Optionally, the light source **12** is attached to and supported by a fixed or movable mounting bracket (not shown). Further, the light source **12** and the semi-reflective mirror **20** may be attached to the first end **34** of the pivotable structure **32** and move in coordination with the pivotable structure **32**.

The light source **12** is operable for generating and transmitting light, such as laser light or the like, to the semi-reflective mirror **20**. The light is then transmitted to the first reflective element **38**, the second reflective element **40**, and the surface **14** of the optical storage medium **16**. The light generated by the light source **12** may be encoded with data or un-encoded. Light from the surface **14** of the optical storage medium **16** is transmitted to the second reflective element **40** and the first reflective element **38**, and is received by a light receiving device **18**, such as a photodiode or the like. Again, the light received by the light receiving device **18** may be encoded with data or un-encoded.

Thus, using the light, the optical path **44** formed between the first reflective element **38** and the second reflective element **40**, and free space optics, data may be read from and/or written to the surface **14** of the optical storage medium **16**. As will be described in greater detail herein below and as is well known to those of ordinary skill in the art, the form and content of this data, its encoding/decoding, and the positioning of the pivotable structure **32** may be controlled by one or more processors/controllers (not shown).

Advantageously, the optical read/write pick-up mechanism **30** of FIG. **2** has relatively fewer components positioned adjacent to the surface **14** of the optical storage medium **16** than conventional optical read/write pick-up mechanisms. Many of these components, such as the voice coil motor, servo mechanism, or the like, are widely used in convention magnetic storage devices. Thus, the optical read/write pick-up mechanism **30** of the present invention is economically efficient and commercially viable. The majority of the components are external to the movable portion(s) of the optical read/write pick-up mechanism **30**. Thus, a relatively higher-powered laser (and therefore a relatively heavier, bulkier light source) may be used, allowing for faster optical read/write speeds while minimizing the mass of the pivotable structure, enabling fast average random access speeds of only a few milliseconds.

As described above, the optical read/write pick-up mechanism of the present invention is designed to provide a relatively light, compact optical read/write head allowing for decreased average random access times. This enhanced access and tracking performance allows the material density of an optical storage medium to be optimized to its theoretical limits. Thus, the optical read/write pick-up mechanism of the present invention performs favorably when compared to conventional magnetic storage devices. In effect, the optical read/write pick-up mechanism of the present invention replaces the magnetic head of a high-density digital disc ("HDD")-based system with a reflective element, such as a microstructure mirror, a MEMS mirror, or the like, and transmits an optical signal over free space or, optionally, by fiber or waveguide. Both fixed and moveable reflective elements may be used to track rapidly while moving the optical read/write head through an arc across the surface of a spinning optical storage medium. Because the pivotable structure pivots at one point, the reflective element may be used to make angular corrections and focus a light beam out of the guided or unguided light source and into the light receiving device, both of which may be disposed at a convenient fixed or moveable location. As is described in greater detail herein below, the reflective element may take a plurality of fixed or moveable forms.

Referring to FIG. **3**, in another embodiment of the present invention, an optical read/write pick-up mechanism **50** operable for reading data from and/or writing data to the surface **14** of an optical storage medium **16**, such as a CD, a DVD, or the like, includes a pivotable structure **52**, such as a pivotable arm or the like, having a first end **54** and a second end **56**. A reflective element **58** is attached to or integrally formed with the second end **56** of the pivotable structure **52**. The second end **56** of the pivotable structure **52** is positioned adjacent to and in a spaced-apart relationship with the surface **14** of the optical storage medium **16**. An actuation device **60**, such as a voice coil motor, a servo mechanism, or the like, is coupled to the first end **54** of the pivotable structure **52** and, when actuated, causes the second end **56** of the pivotable structure **52** to move in an arc parallel to the surface **14** of the optical storage medium **16** while the optical storage medium **16** is spinning. Thus, the reflective element **58** may be positioned adjacent to any selected portion of the surface **14** of the optical storage medium **16**.

A light source **12**, such as a laser diode or the like, and a semi-reflective mirror **20** are positioned in opposing relation to the second end **56** of the pivotable structure **52** and the reflective element **58**. Optionally, the light source **12** and the semi-reflective mirror **20** are attached to and supported by a fixed or moveable mounting bracket (not shown).

The light source **12** is operable for generating and transmitting light, such as laser light or the like, through the semi-reflective mirror **20**. The light is then transmitted to the reflective element **58** and the surface **14** of the optical storage medium **16**. The light generated by the light source may be encoded or un-encoded. Light from the surface **14** of the optical storage medium **16** is transmitted to the reflective element **58** and the semi-reflective mirror **20**, and is received by a light receiving device **18**, such as a photodiode or the like. Again, the light received by the light receiving device **18** may be encoded or un-encoded. Thus, using the light; the optical path **62** formed between the light source **12**, the light receiving device **18**, and the surface **14** of the optical storage medium **16** through the reflective element **58**; and free space optics techniques, data may be read from and/or written to the surface **14** of the optical storage medium **16**. This optical path **62** is further illustrated in FIG. **4**.

Referring to FIG. **5**, in a further embodiment of the present invention, the reflective element **58** is attached to the second end **56** of the pivotable structure **52**. The reflective element **58** may have any curvature in any direction along the reflective element **58**, such as a side curvature or the like, suitable for focusing light and transmitting it to and/or from the surface **14** of the optical storage medium **16** and the light source **12** and/or the light receiving device **18**. Likewise, the reflective element **58** may have any curvature in any direction along the reflective element **58**, such as a top curvature or the like, suitable for compensating for the movement of the pivotable structure **52**. As is shown in FIG. **5**, the light source **12**, the light receiving device **18**, and one or more collimating optics devices **64** may make up a remote optics pick-up module **66**. This remote optics pick-up module **66**, in conjunction with the other components of the optical read/write pick-up mechanism **50** (FIG. **3**), is operable for reading data **68** from and/or writing data **68** to the surface **14** of the optical storage medium **16**.

Referring to FIG. **6**, in a still further embodiment of the present invention, the reflective element **58** attached to or integrally formed with the second end **56** of the pivotable structure **52** is preferably configured such that it maintains a constant 90-degree reflection angle with respect to the remote optical pick-up module **66** as it sweeps an arc **70** across the surface **14** of the optical storage medium **16**. Optionally, the reflective element **58** may take the form of a quarter dome, a half dome, a substantially ellipsoidal/spherical structure, or the like. In the embodiment shown, the remote optical pick-up module **66** is remotely located from and/or is substantially perpendicular to the pivotable structure **52**.

Referring to FIG. **7**, in a still further embodiment of the present invention, the reflective element **40** attached to or integrally formed with the second end **36** of the pivotable structure **32** is also preferably configured such that it maintains a constant 90-degree reflection angle with respect to the remote optical pick-up module **66** as it sweeps an arc **70** across the surface **14** of the optical storage medium **16**. Optionally, the reflective element **40** may take the form of a substantially flat/curved structure or the like. In the embodiment shown, the remote optical pick-up module **66** is coupled to and/or is substantially in line with the pivotable structure **52**. An exemplary optical read/write pick-up mechanism **80** suitable for use with this reflective element configuration is shown in FIG. **8**.

FIGS. **9–12** provide a plurality of alternative embodiments of the optical read/write pick-up mechanism of the present invention. Referring to FIG. **9**, a medium weight optical pick-up module **80** includes a substantially flat reflective element **82**, such as a microstructure mirror, a MEMS mirror, or the like, movably attached to a reflective element actuation device **84**, such as an electrostatic comb drive or the like. Preferably, the reflective element actuation device **84** is operable for selectively rotating the reflective element **82**. Both the reflective element **82** and the reflective element actuation device **84** are attached to the end **86** of the pivotable structure **88**. The medium weight optical pick-up module **80** also includes a beam focuser/expander **90** operable for transmitting light to and/or from the reflective element **82** and the surface **14** of the optical storage medium **16** as shown. As described above, the remote optical pick-up module **66** includes the light source **12**, the light receiving device **18**, and one or more collimating optics devices **64** operable for transmitting light to and/or from the light source **12** and/or the light receiving device **18** and the reflective element **82** as shown.

Referring to FIG. **10**, another medium weight optical pick-up module **92** includes a substantially flat reflective element **82**, such as a microstructure mirror, a MEMS mirror, or the like, movably attached to a reflective element actuation device **84**, such as an electrostatic comb drive or the like. Preferably, the reflective element actuation device **84** is operable for selectively rotating the reflective element **82**. Both the reflective element **82** and the reflective element actuation device **84** are attached to the end **86** of the pivotable structure **88**. The medium weight optical pick-up module **92** or, alternatively, the remote optical pick-up module **66** also includes one or more compensating optical focal length correctors **94** operable for transmitting light to and/or from the light source **12** and/or the light receiving device **18** and the reflective element **82** as shown.

Referring to FIG. **11**, a lightweight optical pick-up module **96** includes a substantially curved reflective element **98**, such as a microstructure mirror, a MEMS mirror, or the like, movably attached to a reflective element actuation device **84**, such as an electrostatic comb drive or the like. Preferably, the reflective element actuation device **84** is operable for selectively rotating the reflective element **98**. In this embodiment, the reflective element **98** has a substantially curved shape suitable for transmitting light to and/or from the light source **12** and/or the light receiving device **18** and the surface **14** of the optical storage medium **16** as shown. Both the reflective element **98** and the reflective element actuation device **84** are attached to the end **86** of the pivotable structure **88**. The remote optical pick-up module **66** includes one or more collimating optics devices **64** operable for transmitting light to and/or from the light source **12** and/or the light receiving device **18** and the reflective element **98** as shown.

Referring to FIG. **12**, another lightweight optical pick-up module **100** includes a substantially curved, deformable reflective element **102**, such as a microstructure mirror, a MEMS mirror, or the like, movably attached to a reflective element actuation device **84**, such as an electrostatic comb drive or the like. Preferably, the reflective element actuation device **84** is operable for selectively rotating the reflective element **102**. In this embodiment, the reflective element **102** has a substantially curved shape suitable for transmitting light to and/or from the light source **12** and/or the light receiving device **18** and the surface **14** of the optical storage medium **16** as shown. The reflective element **102** is deformable and its curvature or shape may be selectively altered using a deformation mechanism **104**. Both the reflective element **102** and the reflective element actuation device **84** are attached to the end **86** of the pivotable structure **88**. The remote optical pick-up module **66** includes one or more collimating optics devices **64** operable for transmitting light to and/or from the light source **12** and/or the light receiving device **18** and the reflective element **98** as shown.

Referring to FIG. **13**, the pivotable structure **32** includes a pivotable arm **110** having a first end **112** and a second end **114**. A first reflective element **116**, such as a reflective mirror or the like, is attached to or integrally formed with the first end **112** of the pivotable arm **110**. A second reflective element **118** is attached to or integrally formed with the second end **114** of the pivotable arm **110**. The second end **118** of the pivotable arm **110** is positioned adjacent to and in a spaced-apart relationship with the surface of an optical storage medium (not shown). An actuation device (not shown), such as a voice coil motor, a servo mechanism, or the like, is coupled to the first end **112** of the pivotable arm **110** and, when actuated, causes the second end **114** of the pivotable arm **110** to move in a arc, parallel to the surface of the optical storage medium while the optical storage medium is spinning. Thus, the second reflective element may be positioned adjacent to any selected portion of the surface of the optical storage medium. Optionally, a light source (not shown) is attached to and supported by a fixed or movable mounting bracket **120**. Alternatively, the light source and a semi-reflective mirror (not shown) may be attached to the first end **112** of the pivotable arm **110** and move in coordination with the pivotable arm **110**.

As described above, in various embodiments, the optical read/write pick-up mechanism of the present invention combines a microstructure or MEMS mirror, micro-optics, and servo control to allow remote pick-up by a fixed-position optical device. The optical read/write pick-up mechanism of the present invention uses a MEMS electrostatic rotary actuator or the like, providing substantial immunity to vibration under closed-loop servo control. This MEMS electrostatic rotary actuator improves relative system performance and reduces relative system cost. The electrostatic control of the microstructure or MEMS mirror provides for active, in-use optical alignment across an optical storage medium to a fixed-position optical target. Low-cost, passive assembly steps may be performed and a wide variety of light sources and light receiving devices may be used, allowing for effective weight/size, power, and thermal management and stability.

Referring to FIG. **14**, one embodiment of an optical media system **130** that may be associated with and use the optical read/write pick-up mechanism of the present invention includes a position control **132** in electrical communication with a voice coil motor ("VCM") actuator **134** or the like. The position control **132** is operable for receiving a track set point **136** and directing the VCM actuator **134** to move the microstructure or MEMS mirror **138** to a predetermined location or to place the microstructure or MEMS mirror **138** in a predetermined orientation. The microstructure or MEMS mirror **138** is in optical communication with the light source **140**, such as the laser diode or the like, and/or the light receiving device **142**, such as the photodiode or the like, with or without an amplifier. The optical media system **130** also includes a position tracker **144** operable for sensing and communicating the position of the VCM actuator **134** and the microstructure or MEMS mirror **138**, and the track error associated therewith, to the position control **132** as a track set point correction **146**. The optical media system **130** further includes a power control **148** and a laser driver **150** operable for powering and controlling the light source **140** and a temperature control **152**, a TEC driver **154**, a temperature sensor **156**, and a TE cooler **158** operable for regulating the temperature of the optical media system **130**.

Referring to FIG. **15**, another embodiment of an optical media system **160** that may be associated with and use the optical read/write pick-up mechanism of the present invention includes a position control **132** in electrical communication with a VCM actuator **134** or the like and one or more mirror drivers **162** or the like. The position control **132** is operable for receiving a track set point **136** and directing the VCM actuator **134** to move the microstructure or MEMS mirror **138** to a predetermined location. The one or more mirror drivers **162** are operable for receiving the track set point **136** and placing the microstructure or MEMS mirror **138** in a predetermined orientation. The microstructure or MEMS mirror **138** is in optical communication with the light source **140**, such as the laser diode or the like, and/or the light receiving device **142**, such as the photodiode or the like, with or without an amplifier. The optical media system **160** also includes a position tracker **144** operable for sensing and communicating the position of the VCM actuator **134** and the microstructure or MEMS mirror **138**, and the track error associated therewith, to the position control **132** as a track set point correction **146**. The optical media system **160** further includes an auto power and focus tracker **170** and focus control **172** operable for sensing and controlling the settings of the light source, and the deviation of these settings from one or more preferred settings. The optical media system **160** still further includes a power control **148** and a laser driver **150** operable for powering and controlling the light source **140** and a temperature control **152**, a TEC driver **154**, a temperature sensor **156**, and a TE cooler **158** operable for regulating the temperature of the optical media system **160**.

With respect to the reflective element described above, and specifically the MEMS mirror, a surface micro-machined ("SMM") mirror or deep reactive ion etched ("DRIE") mirror may be utilized. The SMM mirror is a specialty mirror that incorporates both the optics systems and the actuation systems into one design. The DRIE mirror is also a specialty mirror, however, the optics systems and the actuation systems may be separated. Thus, the DRIE mirror provides a high degree of control and flexibility. Either the SMM mirror or the DRIE mirror may be manufactured using a suitable specialty metal or the like and coated with a specialty coating. These mirrors may be actuated using electrostatic, electromagnetic, or thermal techniques. A LIGA mirror, incorporating a plated metal or the like formed in a high-aspect ratio mold, may also be used. Likewise, a continuous membrane deformable mirror ("CMDM") may also be used.

FIG. **16** illustrates one embodiment of a mirror system **180** that may be used in conjunction with the optical read/write pick-up mechanism of the present invention. The mirror system **180** includes a mirror element **182** actuated by a plurality of combs **184** forming an electrostatic comb drive actuator. The actuation of the mirror element **182** is limited by a mechanical stop **186**. The mirror element **182** is, for example, a lithographically-fabricated Si mirror and may be attached to a plurality of flexural rotary suspensions. The mirror element **182** may be actuated, or rotated, by applying up to about 140V to the electrostatic comb drive actuator **184**. Preferably, about 12–24V are applied to the electrostatic comb drive actuator **184** to actuate, or rotate, the mirror element **182** about a pivot point, allowing for continuous tracking. The electrostatic comb drive actuator **184** may be fabricated in single-crystal Si using DRIE techniques, for example. The relatively high aspect ratio of the plurality of combs **184** provides relatively high out-of-plane stiffness and actuator force.

Referring to FIG. **17**, in a further embodiment of the present invention, a high-capacity optical read/write pick-up mechanism **200** operable for reading data from and/or writing data to the surfaces **14** of a plurality of optical storage media **16**, such as a plurality of CDs, DVDs, or the like, includes a plurality of pivotable structures **202**, such as a plurality of pivotable arms or the like, each of the plurality of pivotable structures **202** having a first end **204** and a second end **206**. A plurality of first reflective elements **208**, such as a plurality of reflective mirrors or the like, are attached to or integrally formed with the first end **204** of each of the plurality of pivotable structures **202**. A plurality of second reflective elements **210** are attached to or integrally formed with the second end **206** of each of the plurality of pivotable structures **202**. The second end **206** of each of the plurality of pivotable structures **202** is positioned adjacent to and in a spaced-apart relationship with the surface **14**, top or bottom, of a predetermined or selected optical storage medium **16**. An actuation device **42**, such as a voice coil motor, a servo mechanism, or the like, is coupled to the first end **204** of each of the plurality of pivotable structures **202** and, when actuated, causes the second end **206** of each of the plurality of pivotable structures **202** to move in an arc, parallel to the surface **14** of the optical storage medium **16** while the optical storage medium **16** is spinning. Thus, each of the plurality of second reflective elements **210** may be positioned adjacent to any selected portion of the surface **14**, top or bottom, of each of the plurality of optical storage media **16**.

A light source **12**, such as a laser diode or the like, and a semi-reflective mirror **20** are positioned in proximity to the first end of each of the plurality of pivotable structures **202** and the plurality of first reflective elements **208**. Optionally, the light source **12** is attached to and supported by a fixed or movable mounting bracket (not shown). Further, the light source **12** and the semi-reflective mirror **20** may be attached to the first end **204** of one of the plurality of pivotable structures **202** and move in coordination with the plurality of pivotable structures **202**.

As described above, the light source **12** is operable for generating and transmitting light, such as laser light or the like, to the semi-reflective mirror **20**. The light is then transmitted to a predetermined or selected one of the plurality of first reflective elements **208**, a predetermined or selected one of the plurality of second reflective elements **210**, and the top or bottom surface **14** of a predetermined or selected one of the plurality of optical storage media **16**. The light generated by the light source **12** may be encoded with data or un-encoded. Light from the surface **14** of the optical storage medium **16** is transmitted to the corresponding second reflective element **210** and the corresponding first reflective element **208**, and is received by a light receiving device **18**, such as a photodiode or the like. Again, the light received by the light receiving device **18** may be coded with data or un-encoded.

Thus, using the light, a predetermined or selected the optical path **212** formed between a given first reflective element **208** and a given second reflective element **210**, and free space optics, data may be read from and/or written to the surface **14**, top or bottom, of a given optical storage medium **16**. As will be described in greater detail herein below and as is well known to those of ordinary skill in the art, the form and content of this data, its encoding/decoding, and the positioning of the plurality of pivotable structures **202** may be controlled by one or more processors/controllers (not shown).

Referring to FIG. **18**, in a first configuration **220** suitable for reading data from and/or writing data to the top surface **222** of one of a plurality of optical storage media **224**, the optical read/write pick-up mechanism **226** of the present invention includes a plurality of pivotable structures **228**. In the example shown, the plurality of pivotable structures **228** include a first pivotable structure **230** and a second pivotable structure **232**. The plurality of optical storage media **224** include a first optical storage medium **234** and a second optical storage medium **236**. A first reflective element **238** is attached to or integrally formed with a first end **240** of the first pivotable structure **230** and a second reflective element **242** is attached to or integrally formed with a second end **244** of the first pivotable structure **230**. A light source/light receiving device **246**, such as a laser diode/photodiode or the like, is disposed adjacent to the first reflective element **238** and is operable for transmitting light, such as laser light, to and receiving light, such as laser light, from the first reflective element **238**, the second reflective element **242**, and the top surface **222** of the first optical storage medium **234** along a first optical path **249** when a third reflective element **248** attached to the first pivotable structure **230** is in a "closed" configuration. The third reflective element **248** may be a MEMS mirror or the like.

Referring to FIG. **19**, in a second configuration **250** suitable for reading data from and/or writing data to the bottom surface **252** of one of a plurality of optical storage media **224**, the optical read/write pick-up mechanism **226** of the present invention includes a plurality of pivotable structures **228**. In the example shown, the plurality of pivotable structures **228** include a first pivotable structure **230** and a second pivotable structure **232**. The plurality of optical storage media **224** include a first optical storage medium **234** and a second optical storage medium **236**. A fourth reflective element **254** is attached to or integrally formed with a first end **256** of the second pivotable structure **232** and a fifth reflective element **258** is attached to or integrally formed with a second end **260** of the second pivotable structure **232**. Again, the light source/light receiving device **246**, such as the laser diode/photodiode or the like, is disposed adjacent to the first reflective element **238** and is operable for transmitting light, such as laser light, to and receiving light, such as laser light, from the first reflective element **238**, the third reflective element **248**, the fourth reflective element **254**, the fifth reflective element **258**, and the bottom surface **252** of the first optical storage medium **234** along a second optical path **259** when the third reflective element **248** attached to the first pivotable structure **230** is in an "open" configuration and a sixth reflective element **262** attached to the first end **256** of the second pivotable structure **232** is also in an "open" configuration. As described above, any or all of the reflective elements may be a MEMS mirror or the like.

Referring to FIG. **20**, in a third configuration **315** suitable for reading data from and/or writing data to the bottom surface **252** of one of a plurality of optical storage media **224**, the optical read/write pick-up mechanism **320** of the present invention includes a plurality of pivotable structures **228**. In the example shown, the plurality of pivotable structures **228** include a first pivotable structure **230** and a second pivotable structure **232**. The plurality of optical storage media **224** include a first optical storage medium **234** and a second optical storage medium **236**. A first reflective element **248** is attached to or integrally formed with a first end **240** of the first pivotable structure **230** and a second reflective element **248** is also attached to or integrally formed with the first end **240** of the first pivotable structure **230**. A third reflective element **310** is attached to or integrally formed with a first end **240** of the second pivotable structure **232** and a fourth reflective element **310** is attached to or integrally formed with a second end **244** of the second pivotable structure **232**. Again, the light source/light receiving device **246**, such as the laser diode/photodiode or the like, is disposed adjacent to the first reflective element **238** and is operable for transmitting light, such as laser light, to and receiving light, such as laser light, from the plurality of reflective elements and the bottom surface **252** of the first optical storage medium **234** along a third optical path **312**. As described above, any or all of the reflective elements may be a MEMS mirror or the like.

FIG. **21** illustrates a plurality of additional optical components that may be utilized in conjunction with the systems and methods of the present invention, including, but not limited to, an optical grating **300**, a collimating lens **302**, a polarizer **304**, a polarizing beam splitter **306**, and a retarder **308**.

Advantageously, the high-capacity optical read/write pick-up mechanism of the present invention allows both sides, top and bottom, of an optical storage medium to be read from and/or written to, effectively doubling the capacity of the current generation of optical storage media. This allows relatively new audio and video compression techniques to be maximized and leveraged.

FIG. **22** illustrates a guided optics configuration of the optical read/write pick-up mechanism of the present invention, as described above, incorporating a laser/photodiode assembly **350**, an optical fiber/waveguide **352**, a moveable pick-up arm **354**, collimating optics **356**, and a reflective parabolic mirror **358**.

It is apparent that there has been provided, in accordance with the systems and methods of the present invention, a high-speed, high-capacity optical read/write pick-up mechanism for use in an optical read/write system. Although the systems and methods of the present invention have been described with reference to preferred embodiments and examples thereof, other embodiments and examples may perform similar functions and/or achieve similar results. All such equivalent embodiments and examples are within the spirit and scope of the present invention and are intended to be covered by the following claims.

What is claimed is:

1. A high-capacity pick-up mechanism operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media, the pick-up mechanism comprising:

a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium;

a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium;

a first reflective element associated with the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium;

a second reflective element associated with the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium;

a light source associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path; and

a light receiving device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path.

2. The pick-up mechanism of claim **1**, wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a second optical storage medium.

3. The pick-up mechanism of claim **2**, further comprising a third reflective element associated with the second end of the second pivotable structure, wherein the third reflective element is operable for transmitting light to and/or receiving light from the top surface of the second optical storage medium.

4. The pick-up mechanism of claim **3**, wherein the light source is operable for transmitting light to the third reflective element along a third optical path.

5. The pick-up mechanism of claim **4**, wherein the first optical path, the second optical path, and the third optical path each comprise an optical path selected from the group consisting of a free space optical path, a fiber-guided optical path, and a waveguide-guided optical path.

6. The pick-up mechanism of claim **3**, wherein the light receiving device is operable for receiving light from the third reflective element along a third optical path.

7. The pick-up mechanism of claim **3**, wherein the first reflective element, the second reflective element, and the third reflective element each comprise a reflective element selected from the group consisting of a microstructure mirror, a moveable micro-electromechanical systems mirror, and a rotatable micro-electromechanical systems mirror.

8. The pick-up mechanism of claim **3**, wherein the second reflective element and the third reflective element are each integrally formed with the second end of the second pivotable structure.

9. The pick-up mechanism of claim **2**, wherein the first optical storage medium and the second optical storage medium each comprise an optical storage medium selected from the group consisting of a compact disc and a digital versatile disc.

10. The pick-up mechanism of claim **1**, further comprising an actuation device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the actuation device is operable for selectively pivoting the first pivotable structure and/or the second pivotable structure such that the second end of the first pivotable structure and/or the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a predetermined portion of the top and/or bottom surface of the first optical storage medium.

11. The pick-up mechanism of claim **10**, wherein the actuation device comprises a voice coil motor.

12. The pick-up mechanism of claim **1**, wherein the first reflective element is integrally formed with the second end of the first pivotable structure.

13. The pick-up mechanism of claim **1**, wherein the light source comprises a laser diode.

14. The pick-up mechanism of claim **1**, wherein the light receiving device comprises a photodiode.

15. A high-capacity optical pick-up mechanism operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media, the optical pick-up mechanism comprising:

a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium;

a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a second optical storage medium;

a first reflective element associated with the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium;

a second reflective element associated with the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium;

a third reflective element associated with the second end of the second pivotable structure, wherein the third reflective element is operable for transmitting light to and/or receiving light from the top surface of the second optical storage medium;

a light source associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path, and wherein the light source is operable for transmitting light to the third reflective element along a third optical path; and

a light receiving device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path, and wherein the light receiving device is operable for receiving light from the third reflective element along the third optical path.

16. The optical pick-up mechanism of claim **15**, further comprising an actuation device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the actuation device is operable for selectively pivoting the first pivotable structure and/or the second pivotable structure such that the second end of the first pivotable structure and/or the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a predetermined portion of the top and/or bottom surface of the first optical storage medium and/or the top surface of the second optical storage medium.

17. The optical pick-up mechanism of claim **16**, wherein the actuation device comprises a voice coil motor.

18. The optical pick-up mechanism of claim **15**, wherein the first reflective element, the second reflective element, and the third reflective element each comprise a reflective element selected from the group consisting of a microstructure mirror, a moveable micro-electromechanical systems mirror, and a rotatable micro-electromechanical systems mirror.

19. The optical pick-up mechanism of claim **15**, wherein the first reflective element is integrally formed with the second end of the first pivotable structure.

20. The optical pick-up mechanism of claim **15**, wherein the second reflective element and the third reflective element are each integrally formed with the second end of the second pivotable structure.

21. The optical pick-up mechanism of claim **15**, wherein the light source comprises a laser diode.

22. The optical pick-up mechanism of claim **15**, wherein the first optical path, the second optical path, and the third optical path each comprise an optical path selected from the group consisting of a free space optical path, a fiber-guided optical path, and a waveguide-guided optical path.

23. The optical pick-up mechanism of claim **15**, wherein the light receiving device comprises a photodiode.

24. The optical pick-up mechanism of claim **15**, wherein the first optical storage medium and the second optical storage medium each comprise an optical storage medium selected from the group consisting of a compact disc and a digital versatile disc.

25. A high-capacity optical read/write device, the optical read/write device comprising:

a high-capacity pick-up mechanism operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media, the pick-up mechanism comprising:

a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium;

a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium;

a first reflective element associated with the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium;

a second reflective element associated with the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium;

a light source associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path; and

a light receiving device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path.

26. The optical read/write device of claim **25**, wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a second optical storage medium.

27. The optical read/write device of claim **26**, further comprising a third reflective element associated with the second end of the second pivotable structure, wherein the third reflective element is operable for transmitting light to and/or receiving light from the top surface of the second optical storage medium.

28. The optical read/write device of claim **27**, wherein the light source is operable for transmitting light to the third reflective element along a third optical path.

29. The optical read/write device of claim **28**, wherein the first optical path, the second optical path, and the third optical path each comprise an optical path selected from the group consisting of a free space optical path, a fiber-guided optical path, and a waveguide-guided optical path.

30. The optical read/write device of claim **27**, wherein the light receiving device is operable for receiving light from the third reflective element along a third optical path.

31. The optical read/write device of claim **27**, wherein the first reflective element, the second reflective element, and the third reflective element each comprise a reflective element selected from the group consisting of a microstructure mirror, a moveable micro-electromechanical systems mirror, and a rotatable micro-electromechanical systems mirror.

32. The optical read/write device of claim **27**, wherein the second reflective element and the third reflective element are each integrally formed with the second end of the second pivotable structure.

33. The optical read/write device of claim **26**, wherein the first optical storage medium and the second optical storage medium each comprise an optical storage medium selected from the group consisting of a compact disc and a digital versatile disc.

34. The optical read/write device of claim **25**, further comprising an actuation device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the actuation device is operable for selectively pivoting the first pivotable structure and/or the second pivotable structure such that the second end of the first pivotable structure and/or the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a predetermined portion of the top and/or bottom surface of the first optical storage medium.

35. The optical read/write device of claim **34**, wherein the actuation device comprises a voice coil motor.

36. The optical read/write device of claim **25**, wherein the first reflective element is integrally formed with the second end of the first pivotable structure.

37. The optical read/write device of claim **25**, wherein the light source comprises a laser diode.

38. The optical read/write device of claim **25**, wherein the light receiving device comprises a photodiode.

39. A high-capacity optical read/write system, the optical read/write system comprising:

a high-capacity optical pick-up mechanism operable for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media, the optical pick-up mechanism comprising:

a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium;

a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a second optical storage medium;

a first reflective element associated with the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium;

a second reflective element associated with the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium;

a third reflective element associated with the second end of the second pivotable structure, wherein the third reflective element is operable for transmitting light to and/or receiving light from the top surface of the second optical storage medium;

a light source associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path, and wherein the light source is operable for transmitting light to the third reflective element along a third optical path; and

a light receiving device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path, and wherein the light receiving device is operable for receiving light from the third reflective element along the third optical path.

40. The optical read/write system of claim **39**, further comprising an actuation device associated with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the actuation device is operable for selectively pivoting the first pivotable structure and/or the second pivotable structure such that the second end of the first pivotable structure and/or the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a predetermined portion of the top and/or bottom surface of the first optical storage medium and/or the top surface of the second optical storage medium.

41. The optical read/write system of claim **40**, wherein the actuation device comprises a voice coil motor.

42. The optical read/write system of claim **39**, wherein the first reflective element, the second reflective element, and the third reflective element each comprise a reflective element selected from the group consisting of a microstructure mirror, a moveable micro-electromechanical systems mirror, and a rotatable micro-electromechanical systems mirror.

43. The optical read/write system of claim **39**, wherein the first reflective element is integrally formed with the second end of the first pivotable structure.

44. The optical read/write system of claim **39**, wherein the second reflective element and the third reflective element are each integrally formed with the second end of the second pivotable structure.

45. The optical read/write system of claim **39**, wherein the light source comprises a laser diode.

46. The optical read/write system of claim **39**, wherein the first optical path, the second optical path, and the third optical path each comprise an optical path selected from the group consisting of a free space optical path, a fiber-guided optical path, and a waveguide-guided optical path.

47. The optical read/write system of claim **39**, wherein the light receiving device comprises a photodiode.

48. The optical read/write system of claim **39**, wherein the first optical storage medium and the second optical storage medium each comprise an optical storage medium selected from the group consisting of a compact disc and a digital versatile disc.

49. A high-capacity method for selectively reading data from and/or writing data to one or more surfaces of one or more optical storage media, the method comprising:

providing a first pivotable structure having a first end and a second end, wherein the first end of the first pivotable structure is located remotely from the second end of the first pivotable structure, and wherein the second end of the first pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a first optical storage medium;

providing a second pivotable structure having a first end and a second end, wherein the first end of the second pivotable structure is located remotely from the second end of the second pivotable structure, and wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a bottom surface of the first optical storage medium;

disposing a first reflective element in proximity to the second end of the first pivotable structure, wherein the first reflective element is operable for transmitting light to and/or receiving light from the top surface of the first optical storage medium;

disposing a second reflective element associated in proximity to the second end of the second pivotable structure, wherein the second reflective element is operable for transmitting light to and/or receiving light from the bottom surface of the first optical storage medium;

disposing a light source in proximity to both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light source is operable for transmitting light to the first reflective element along a first optical path, and wherein the light source is operable for transmitting light to the second reflective element along a second optical path; and

disposing a light receiving device in proximity to both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the light receiving device is operable for receiving light from the first reflective element along the first optical path, and wherein the light receiving device is operable for receiving light from the second reflective element along the second optical path.

50. The method of claim **49**, wherein the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a top surface of a second optical storage medium.

51. The method of claim **50**, further comprising disposing a third reflective element associated in proximity to the second end of the second pivotable structure, wherein the third reflective element is operable for transmitting light to and/or receiving light from the top surface of the second optical storage medium.

52. The method of claim **51**, wherein the light source is operable for transmitting light to the third reflective element along a third optical path.

53. The method of claim **52**, wherein the first optical path, the second optical path, and the third optical path each comprise an optical path selected from the group consisting of a free space optical path, a fiber-guided optical path, and a waveguide-guided optical path.

54. The method of claim **51**, wherein the light receiving device is operable for receiving light from the third reflective element along a third optical path.

55. The method of claim **51**, wherein the first reflective element, the second reflective element, and the third reflective element each comprise a reflective element selected from the group consisting of a microstructure mirror, a moveable micro-electromechanical systems mirror, and a rotatable micro-electromechanical systems mirror.

56. The method of claim **51**, wherein the second reflective element and the third reflective element are each integrally formed with the second end of the second pivotable structure.

57. The method of claim **50**, wherein the first optical storage medium and the second optical storage medium each comprise an optical storage medium selected from the group consisting of a compact disc and a digital versatile disc.

58. The method of claim **49**, further comprising coupling an actuation device with both the first end of the first pivotable structure and the first end of the second pivotable structure, wherein the actuation device is operable for selectively pivoting the first pivotable structure and/or the second pivotable structure such that the second end of the first pivotable structure and/or the second end of the second pivotable structure is positioned adjacent to and in a spaced-apart relationship with a predetermined portion of the top and/or bottom surface of the first optical storage medium.

59. The method of claim **58**, wherein the actuation device comprises a voice coil motor.

60. The method of claim **49**, wherein the first reflective element is integrally formed with the second end of the first pivotable structure.

61. The method of claim **49**, wherein the light source comprises a laser diode.

62. The method of claim **49**, wherein the light receiving device comprises a photodiode.

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